Walter J. Spielberger

Gepard

The History of German Anti-Aircraft Tanks

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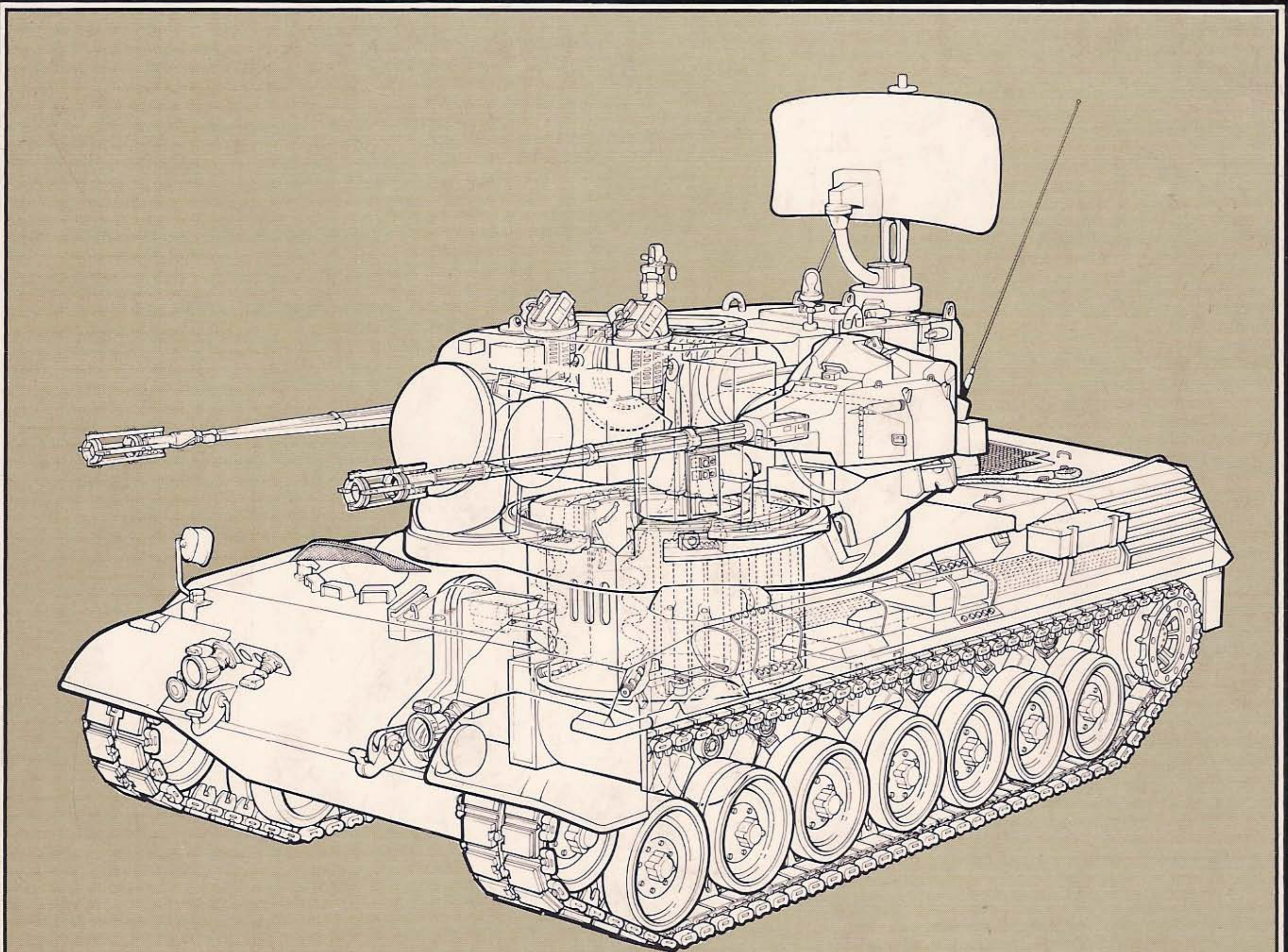

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The History of German Anti-Aircraft Tanks

with 291 photographs, 173 drawings and diagrams,
2 colored prints, and many tables

Bernard & Graefe, Munich

The photo on the book jacket shows a phantom drawing of the Anti-aircraft tank Gepard

Drawings by Hilary L. Doyle

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Contents

Preface

This book presents for the first time a comprehensive synopsis of the long journey which the technological development of Air Defense has travelled, from the initial conception of the Anti-Balloon Cannon in the year 1870, to to-day's highly complex Anti-Aircraft, Gun and Missile Tanks.

For many years past, weapons and weapon systems used by other branches of the Armed Services have been documented their histories and legends published.

Most of the pertinent material relating to the historical development of anti-aircraft tanks, has lain dormant, often forgotten in a variety of National, Military or Company Archives.

It is to the authors credit that the authorative material he has collected and painstakingly prepared, provides, published in the form of this book, interesting reading for the general public.

More so, since air defense weapons and fire control technology is not only in itself a fascinating specialized area of military technology, many of the equipments and processes integrated within these systems have provided wide reaching impulses into other areas of industry, The application of computers in fire control equipment, the use of radar for measuring range, the combination of sensors, computers and weapons into kybernetic closed systems, all of these developments were first realised in air defense applications of one sort or another.

Behind the moderate descriptions and technical data this book contains, it is possible to discern the continually increasing growth of the threat from the sky, a threat which became more and more apparent as World War II progressed. This is expressively confirmed by the increasing priority, urgency and frequency of the demands by both the troops in the field and the General Staff for the faster development of suitable defensive weapon systems. Naturally, these demands led to many hasty, often uncoordinated attempts being made in their realisation. In spite of many excellent technical solutions conceived, one cannot avoid receiving an impression of giant and chaotic administrative deficiencies. All this in spite of the "total war" conditions which applied at that time.

Alternatively however, it is clear to see, that todays Anti-Aircraft, Gun and Missile Tanks, in their basic and technical concepts, retain in various degrees the influence of World War II experiencies. Their realisation with the means we have at our disposal to-day cannot alter these facts.

This book therefore serves to remind, as that all who have and will in future years contribute to our national security and that of our Central European neighbours, have been or will be links of a very long chain.

Helmut Schüler

Helmut Schüler
Brigadier (Retd.)
Commander Army Air Defense
(1968–1974)

Introduction

On October 29th, 1980 the last of the "Gepard" Anti-Aircraft Tanks procured for the German Army was officially handed over by Krauss Maffei AG, at their factory in Munich.

The book you are about to read describes in chronological order the many developments of this form of ordnance, in the years between the initial conception of the Anti-Balloon Cannon and that of one of the most complex and sophisticated, modern Anti-Aircraft Tanks to have ever been manufactured.

Although the history of the German Anti-Aircraft Tank has had many facets of its own, it has also, in the main, remained very closely associated with the development of the tank.

In parallel with the very rapid development of jet powered combat aircraft and their ever increasing all-weather capabilities, more and more demanding technological and/or electronic requirements have had to be established for both to-days air defense systems and those of the future. It is therefore perfectly clear that in order to provide modern armies, in the field, with effective air cover that the modern anti-aircraft tanks must possess the highest possible standards of mobility, fire power and armored protection. Furthermore other important features are also essential, maximum standards of reliability and availability for extended periods of time cannot be ignored. It has only been possible to meet these many and various demands by the consequential application of the latest electronic and optronic technologies to provide such effective air defense. This book, which I hope, in years to come, will serve as an authorative reference to those interested, particular attention has been paid to the technological development aspects. Not only those developments considered as successes have been described, other little known developments where results were negative or unsuccessful are also included. This has been done in order to provide, to you the reader, an almost complete documentary account of German self-propelled Air Defense development. From its initial inception with the development of the Anti-Balloon Cannon right through until the end of World War II in 1945, all other developments which were and have remained unknown until now have also been included.

Systems used by the German Armed Forces (the Bundeswehr) when they were formed in 1955, until they were replaced when the "Gepard" Anti-Aircraft and "Roland" Missile Tanks entered into service have also been covered. In order to illustrate modern post-war trends, the book closes with documentation covering future oriented new developments.

I should like to express my most sincere thanks and appreciation for their most valuable assistance to:

– Ing. (grad.) Udo Brandes – Oberst a. D. Dipl.-Ing. Theodor Icken – Hans C. Graf von Seherr-Thoss

this also includes the many other specialists who also provided advice and support during compiling this book.

Spielberger

Walter J. Spielberger

1. The years 1870 to 1914

From almost the very beginning, the possible use of the aeroplane for military applications had been closely scrutinised, progress in these fields however had been plagued and delayed by technical problems. But, those likely to be most affected by such developments were already considering how this new threat from the skies could be countered.

As early as 1870/ 71, when Prussian troops were laying siege to Paris, need arose for some means of combating aerial targets.

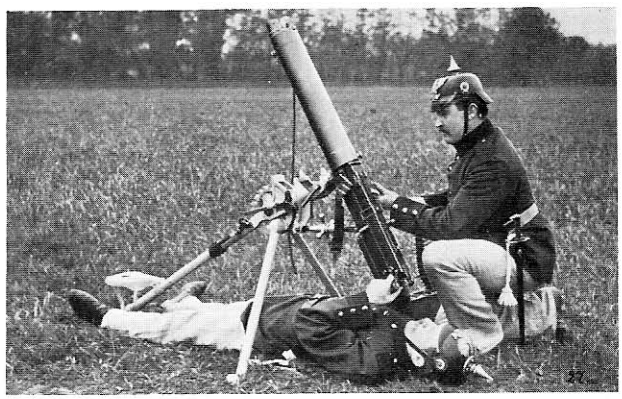
The beleaguered Parisians were using free-flying manned balloons for liaising with unoccupied France. On November 12th, 1870 Prussian gunners succeeded in shooting down their first of these balloons. They were able to do this by employing an Anti-Balloon Cannon especially designed and manufactured for this purpose by Friedrich Krupp of Essen. This event could be entered in the annals of history as being the day German Anti-Aircraft Artillery was born.

In later years this same 3.7 cm cannon was still to be found in service, mounted on a pivoted socket tri-pod fixed to four-wheeled, flat-bed horse drawn wagons. An arrangement which provided some amount of mobility and operational independance.

By 1900 however these flat-bed wagons proved to be no longer suitable. They moved far to slowly and could not be used in every kind of terrain against airships (Zeppelins) and aircraft.*The automobile offered itself as a possible new solution.

*The Wright Brothers first piloted powered flight took place on December 17th, 1903.

The very first anti-aircraft defense. A Dreyse machine-gun deployed against both ground and aerial targets.



The armored road vehicle which Paul Daimler built in 1903, in Wiener Neustadt clearly demonstrated the more than obvious advantages offered by four-wheel drive vehicles. In spite of this, the Military Authorities seemed very reluctant in deciding upon further development of such vehicles.

In fact, in the opinion of the German Military Vehicle Inspectorate, such powered vehicles belonged purely on good macadamised roads. For movement across terrain and dirt roads only

Displayed at the 1906, Berlin Motor Show an armored car manufactured by the Ehrhardt Co., of Zella St. Blasii. Armed with a 5 cm, L/30 Anti-Balloon Cannon made by Rheinmetall.

horses could be considered as being satisfactory sources of traction. So influential were these opinions that eventually, in 1908 the Prussian Army discontinued all further trials of fourwheeled drive vehicles. The reasons given were their being to heavy and complicated to be introduced into service when compared to the normal military trucks already in service. which only had driven rear axles.

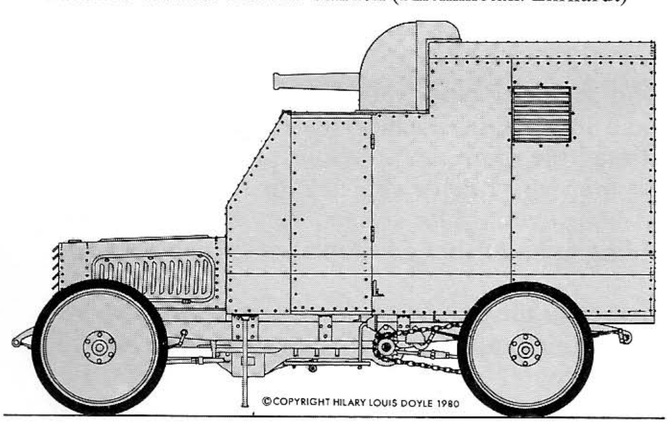
At the beginning of 1906, the Artillery Trials Board of the Prussian War Ministry ordered that investigative trials should be carried out. The objectives of these trials being to study how far both field and heavy artillery could be tactically deployed against aerial targets. Any special procurement of suitable ordnance and diversion of special troops for this purpose becoming therefore purely a matter of conjecture.

Around about this time the companies, Krupp of Essen, Rheinische Metallwaaren and Maschinenfabrik (Rheinmetall) of Düsseldorf and Ehrhardt, Zella-St, Blasii, were all pre-occupied with this same problem. One solution, created by Ehrhardt was an armored car, armed with a 5 cm caliber Anti-Balloon Cannon, which was exhibited at the 1906 Berlin Motor Show. This weapon was mounted on a standard truck chassis with chain-driven rear wheels. Its 60 HP petrol engine enabled gradients of up to 22% to be negotiated and gave a top speed of 45 km/h.

The 5 cm cannon was intended for engaging both observation balloons or aircraft. The weapon itself was mounted in a centrally pivoting gun cradle (MPW-Cradle) M/06. On-board ammunition supply consisted of one hundred grenade and fragmentary shells. Weapon elevation ranged from –5° to +70°, field-of-traverse was limited at 60°. Initial muzzle velocity of the grenade was 572 m/s, that of the fragmentation round 450 m/s. Maximum range of the detonator fuse was four thousand two hundred meters. It was planned that these weapons would be deployed by training their fire at an aerial target, the resulting fire and barrage of fragments thereby forcing the aircraft to abort its mission. All-round, 3 mm thick armor ensured the vehicles protection against infantry small-arms fire.

Access door, surveillance apertures and gun port could all be closed, the forward section of the structure lifted upwards. The massive cannon barrel was retained in its forked pintle by means of

Mobile 5 cm Anti-Balloon Cannon (Rheinmetall/Ehrhardt)

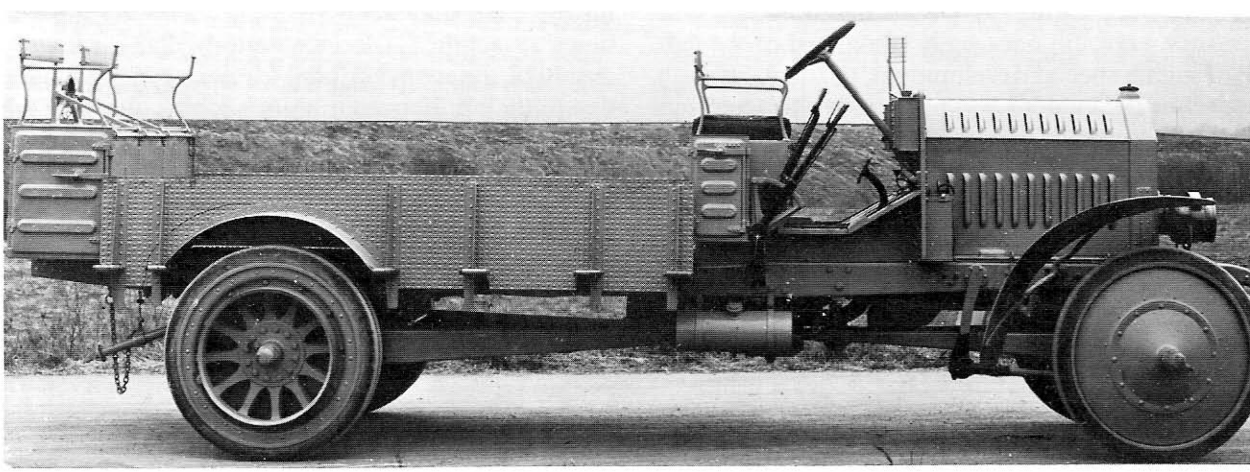


lateral journals, the pintle completely encircled the barrel, retaining both the recoil damping cylinder and counter-recoil spring with its upper section. Weapon traversing was done using a shoulder-butt secured at the forked pintle, it could be fastened by means of a set-screw. Elevating the weapon was done gradually by means of a manually operated fly-wheel and worm-gear, this drive could be quickly disengaged to facilitate greater elevational movement when required. Tangential movement could be carried out by means of a second worm gear and graduated protractor disc. It was planned to install an adjustable telescopic sight. Total weight of the vehicle, fully equipped with ammunition and five man crew was 3.2 tons.

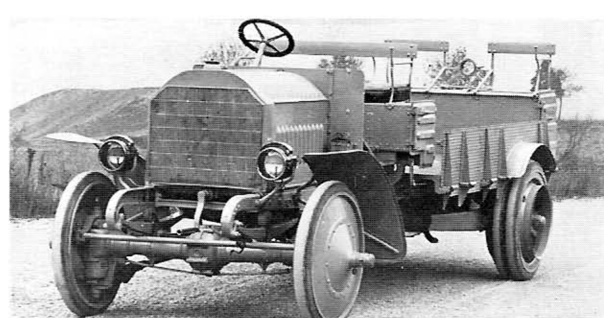
Rheinmetall also exhibited their 5 cm Anti-Balloon Cannon, the L/30 which had a similar centrally pivoting MPW Gun Cradle. This was also mounted upon an Ehrhardt truck chassis, one additional advantage of this concept was that the cannon could be freely traversed through 360°.

The Prussian War Ministry remained adamant that it was unnecessary to develop special ordnance for air defense and insisted that standard army field ordnance continue being deployed for this purpose.

In the year 1908, the Daimler Motor Co., in Untertürkheim constructed a new platform truck, specially designed for mounting an Anti-Balloon Cannon. Krupp of Essen, contributing the ordnance, their newly developed 7.7 cm caliber L/30 Anti-Ballon Cannon, which with its socket mounting was particulary suited for such truck installations. The incendiary shell planned for use with this weapon had a percussion fuse, a muzzle velo-



The first Daimler Platform Truck from 1908. This was a four-wheel drive vehicle for mounting an anti-balloon cannon. Mounted as armament is the 7.7 cm, L/30 swivel-mounted, anti-balloon cannon, newly developed by Krupp.



city of 650 m/s and a ceiling altitude of 6500 meters. Field of elevation ranged from –5° to +75°. The Daimler, four cylinder, type M 1454 petrol engine had a power output of 52 HP at 820 r.p.m. Transmission was a crash gearbox with four forward and one reverse gears, differential locking increased the vehicles cross-country capability. This vehicle was eventually converted into a gun-transporter and fitted with a hinged loading ramp, manually raised/lowered using a block and tackle.

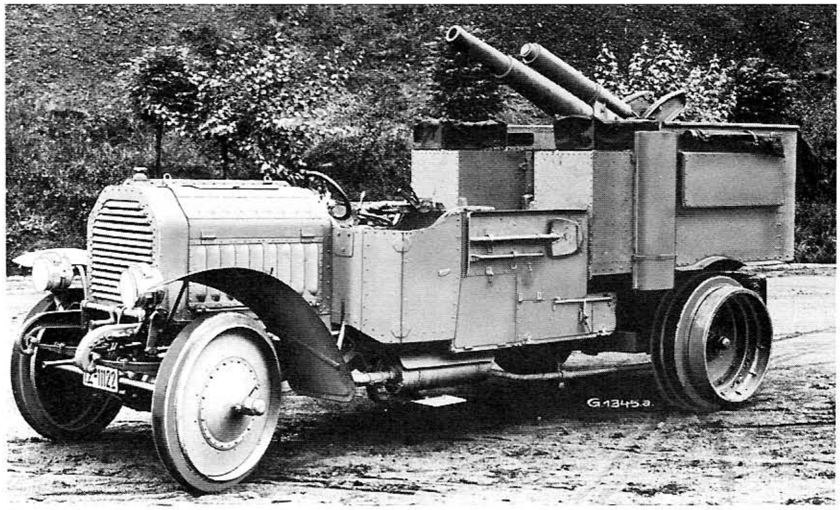
At the same time, Rheinmetall developed a 6.5 cm caliber Anti-Balloon Cannon suitable for mounting on platform trucks. Field-of-elevation of this weapon was given as being –5° to +75°, With a ceiling altitude of 7900 meters, muzzle velocity for both the dually fused fragmentation and grenade shells was 670 m/s. The weapon was mounted on an Ehrhardt truck.

However, the General Staff at the Prussian War Ministry were still not totally convinced of the value of such a special development, particularly with respect to the evident and numerous shortcomings still to be found in the motor vehicles of that time. Therefore the Prussian War Ministry made what could only be viewed as a compromise decision, by procurring a 7.7 cm Anti-Balloon Cannon, suitable for mounting on either a low-bed, horse-drawn wagon or alternatively, socket mounted on a platform-truck. In both cases mechanical devices for rapid gun-laying were proposed.

The notion of using truck platforms for carrying mounted Anti-Balloon Cannon gained support during successful field trials by the troops. During the Kaiser's Manœvres in 1910, it was repeatedly demonstrated how a truck-mounted Anti-Balloon Cannon was able to hinder and block an airship from proceeding on its course. As the airship flew at altitudes of only 100 to 200 meters, in wartime conditions it would most surely have fallen an easy victim to the Balloon Cannon. The pivoted cannon proved itself to be particulary suited for deployment against aerial targets, hereto it also emerged, that such a truck required much less time to change its position than the horse-drawn wagons. Vehicle mounted ordnance furthermore, meant that the weapons were also capable of being in action for longer periods than ordnance mounted on conventional drawn gun carriages due to their enhanced mobility. It was also conclusively proved that such a rapid deployment capability was a vital asset in providing air defense in sensitive areas i.e: de-training or disembarkation of a new army division.

Rheinische Metallwaaren and Maschinenfabrik, Düsseldorf, presented their semi-armored, 5 cm Anti-Balloon Cannon Truck, the C/1908 in 1908.

Daimlers, 1910 Platform Truck was an improved version of the 1908 model. A more powerful engine was installed, the suspension could be locked when firing.



In 1910 Daimler presented a further development of the platform truck. Besides the installation of a more powerful engine, a type M 1464, the chassis frame rose sharply upwards over the rear axle. The vehicle had a wheelbase of 3840 mm, the front and rear wheel track widths were 1600/1674 mm respectively, the transmission remained unchanged. For stabilising purpose the suspension could be manually locked using a crank/flywheel combination. Cable warps for recovering the vehicle when it was bogged down in deep soft ground were mounted at the hubs of both the front and rear wheels.

1911, saw the two competing manufacturers, Krupp-Daimler and Rheinmetall-Ehrhardt pre-

The Rheinmetall version of the 7.7 cm, socket-mounted anti-aircraft cannon, during firing trials.

The 1911, Daimler Platform Truck Prototype, only one of which was produced. Mounted as armament ist the 7.7 cm L/27 Anti-Balloon Cannon designed by Krupp.

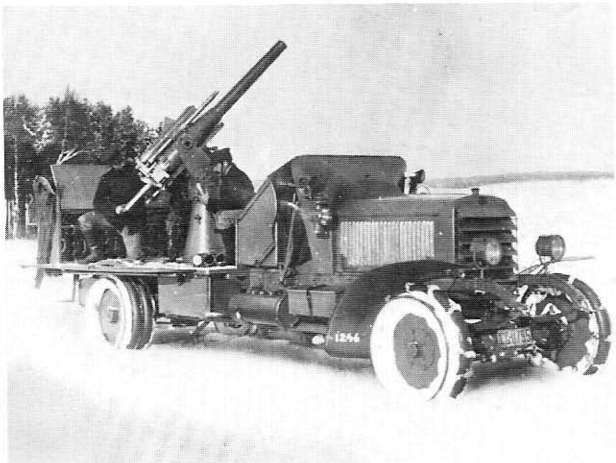
senting their type 1911, platform truck concepts to the Prussian War Ministry for consideration. The Krupp-Daimler concept retaining both its original engine and wheelbase, only the track widths having been increased to 1536/1706 mm. A new transmission, with two final drive shafts, providing eight forward and two reverse gears was offered however. Mounted on the trucks gun-platform was a new lightweight 7.7 cm caliber, L/27 Type M 1911, vehicle Anti-Balloon Cannon. Only one demonstration prototype of this vehicle was built.

Although in 1911/12, the Inspectorate General of Military Vehicles had declared as closed all new road-bound vehicle developments, in 1911/13 further trials took place. These trials were to investigate "Devices for driving vehicles on dirt and gravel tracks." It is more than likely that these trials took place at the instigation and insistance of the Artillery. Resulting no doubt from their needs of not only providing air defense but also for transporting heavy field ordnance in areas not accessible or without railway facilities.

Section 4 of the General War Department of the Prussian War Ministry, then ordered that production of the "1912 Anti-Balloon Cannon" be started. With the companies Krupp/Daimler and Rheinmetall/Ehrhardt working together. The Krupp M 1911 Cannon was to have the widest field-of-elevation attainable and would be mounted on a four-wheel driven, 70 HP truck. Since built-up roads, would in case of war be overloaded by troop movements, the Anti-Ballon Cannon truck was supposed to be capable of fully utilising dirt roads and tracks. In order to increase the automotive performance of these vehicles they were exclusively equipped with four-wheel drive. Furthermore, cross-country performance was to be improved by fitting "sandrims" to the standard wheels, these rims only came into play as the vehicle sank into soft ground.

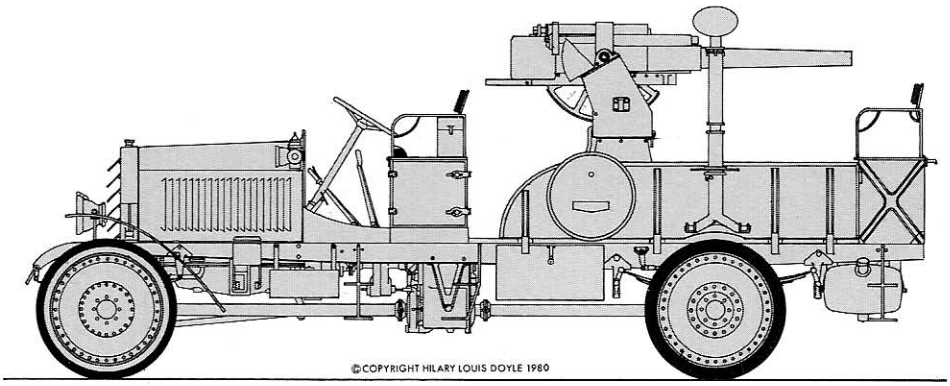
Although the Prussian War Ministry were of the opinion that it would not be possible to pursue fast moving aerial targets from the ground, they nevertheless established a requirement for a more powerful, 80 HP engine. It also seemed obvious that four forward gears were not going to suffice. At lower speeds it was considered that an additional intermediate reduction gear was desirable. It was because of this trend that Ehrhardt included two additional reduction gears. One being interspersed between first and second gears, and one between

As a contemporary to the Krupp/Daimler vehicle, Rheinische Metallwaaren and Maschinenfabrik, Düsseldorf, delivered 1911 Platform Truck Prototypes, armed with their 7.7 cm, L/27 C, 1911 Anti-Balloon Vehicle Cannon.



Rheinmetall's 1912 Cannon Truck, again utilising automotive components from the Ehrhardt Co. As previously, the Rheinmetall, L/27 C 1911 Anti-Balloon Cannon is mounted.

7.7 cm Anti-Balloon Cannon, mounted on the 1912 model Cannon Truck (Rheinmetall/ Ehrhardt)



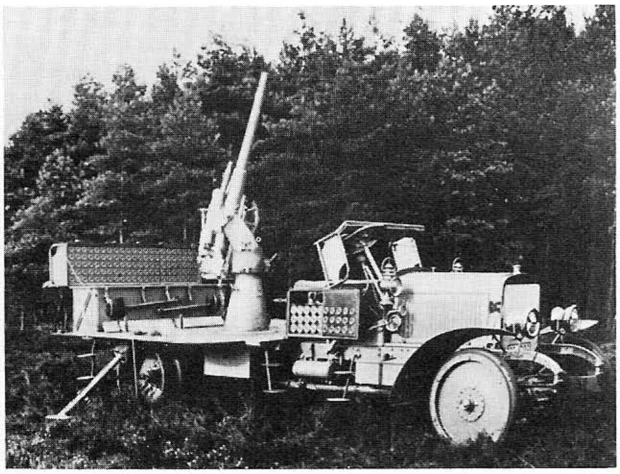
third and fourth gears. Daimler however chose to install an intermediate geared drive. The major draw-back with this solution was that prior to the driver commencing cross-country journeys the vehicle had to be brought to a halt to change into the intermediate gear.

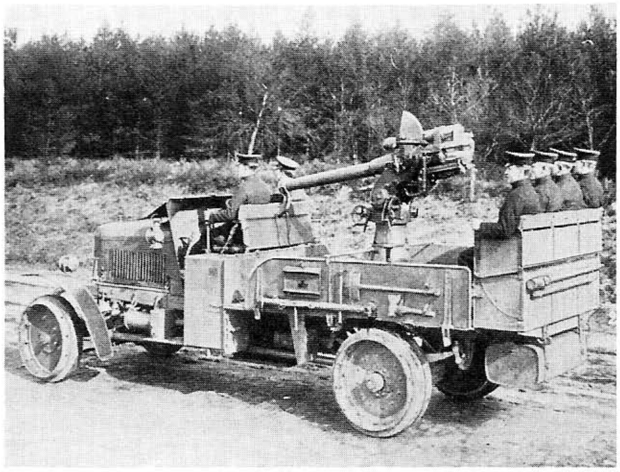
The good automotive characteristics of the motorised Anti-Balloon Cannon served to revive discussions of the long forgotten past. Differing opinions concerning the merits and draw-backs of both two and four wheeled drive were expressed once more. Both the Artillery and Transport Engineering Proving Commissions diligently investigated other possible applications for four-wheel drive. However four-wheel drive vehicles due to their cost intensive technology, increased weight and procurement costs were far less likely to be introduced into service than conventional vehicles. It was due to this that the Prussian War Ministry considered it to be impossible to procure the quantities of these vehicles which the Army considered as being necessary, The three major reasons were given as procurement costs, danger of possible obsolescence during storage in Army Arsenals, and the still incomplete military requirements for a total cross-country capability. So therefore the Prussian War Ministry decided that four-wheel drive would remain restricted for use on small numbers of special purpose vehicles.

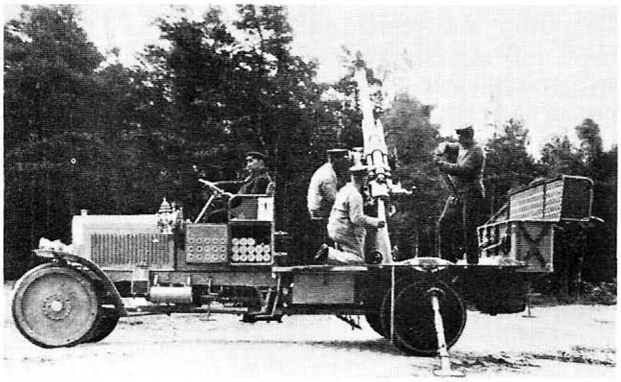
In 1913, the Heinrich Ehrhardt Co., developed an improved four-wheel drive, platform truck. This vehicle complete with a light, 7.7 cm caliber Anti-Balloon Cannon was type designated as the L/27, 1914. Some considerable numbers of this vehicle were produced and handed over the Army Administration for trials.

To power the vehicle, a four-cylinder, 130 mm bore, 150 mm stroke, petrol engine had been installed, which was directly mounted on the reinforced steel sheet chassis frame. The power outout of the engine was 50 HP. Engine power was transferred via a conical clutch to the gearbox, which was centrally suspended from the underside of the chassis frame and had four forward and one reverse gears. A third drive shaft, positioned beneath both of the standard drive shafts served for distributing tractive power to all four wheels.

Also in 1913, Krupp placed an order with Daimler for two, "1913 Platform Trucks." These vehicles had been developed during the interim period by Daimler-Untertürkheim, at the initiative and responsibility of the Friedrich Krupp GmbH of Essen. Already at this time, as later during the war, all contracts for self-propelled gun carriages and motor tractors were placed via Krupp. Daimler had in fact already contractually committed themselves to Krupp to exclusively deliver these specific types of vehicles, an agreement unknown to the Army Administration at that time. Compared with the 1911 model of the platform truck, the "1913 Platform Truck" hat not been drastically changed. The same wheelbase dimension was retained, track widths had been increased to 1530/ 1678 mm respectively. Power output from the engine was 70 HP. Total weight of the vehicle, complete with its 7.7 cm caliber, light gun L/27, Model 1914, was 7035 kg. A complement of ten soldiers was planned for manning the vehicle.

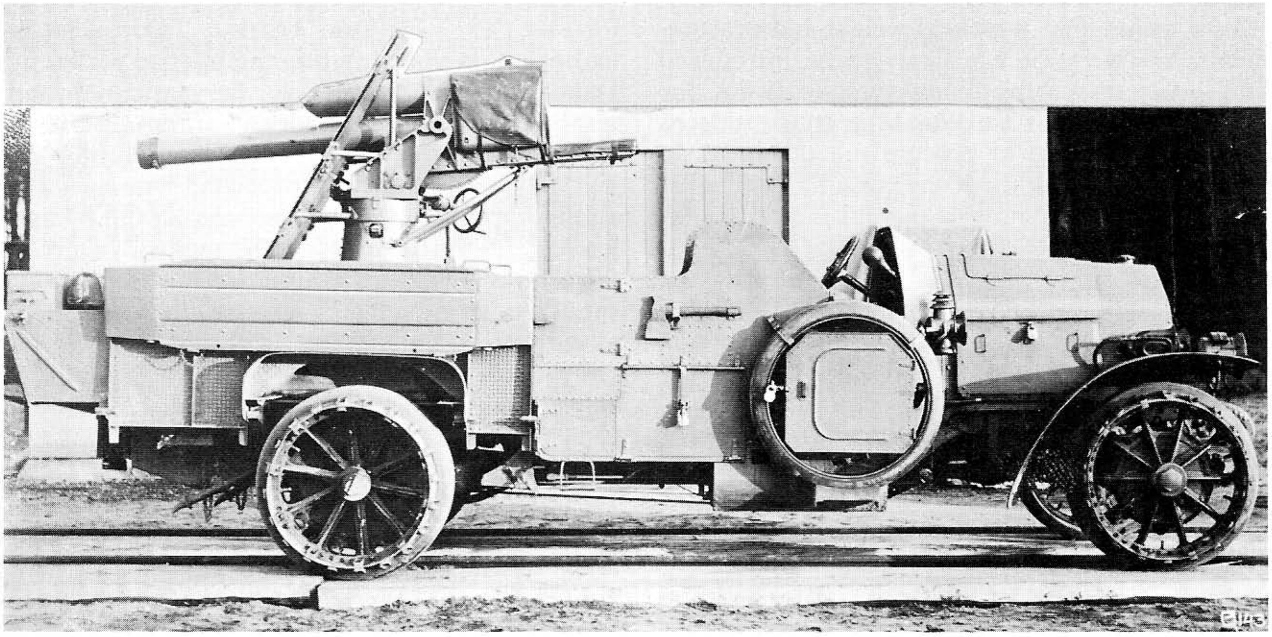


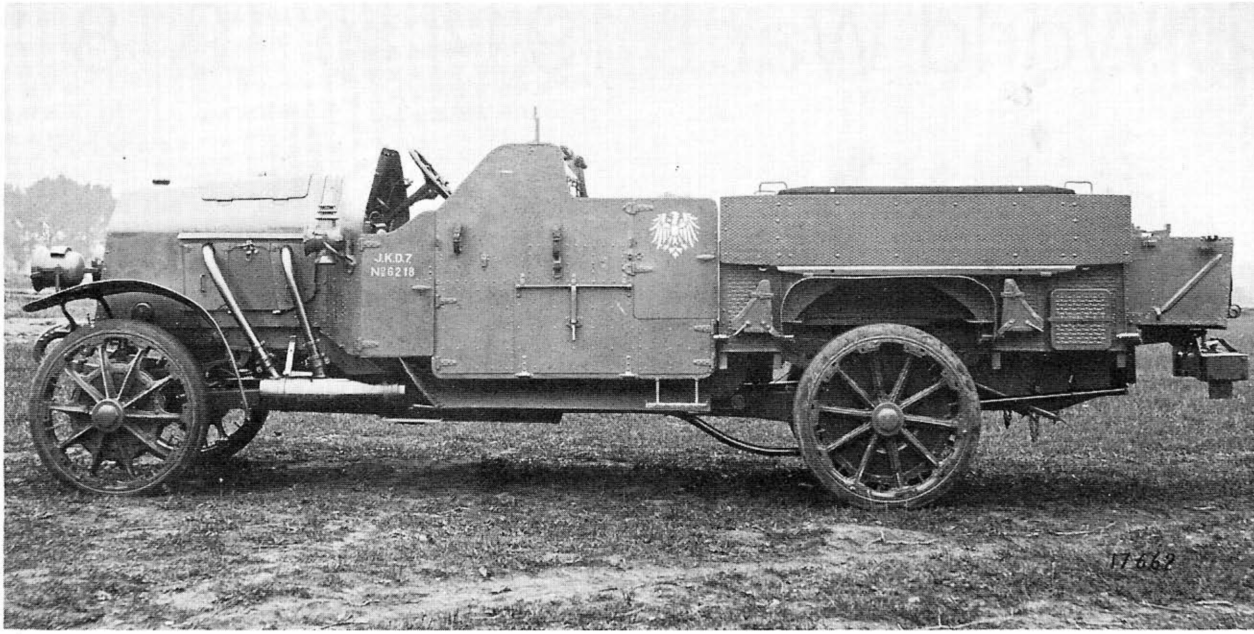




In 1913, Rheinmetall designed and built an improved, four-wheel drive, platform-truck for mounting their 7.7 cm, L/27, C 1914 Anti-Balloon Cannon. A considerable number of these systems was manufactured.

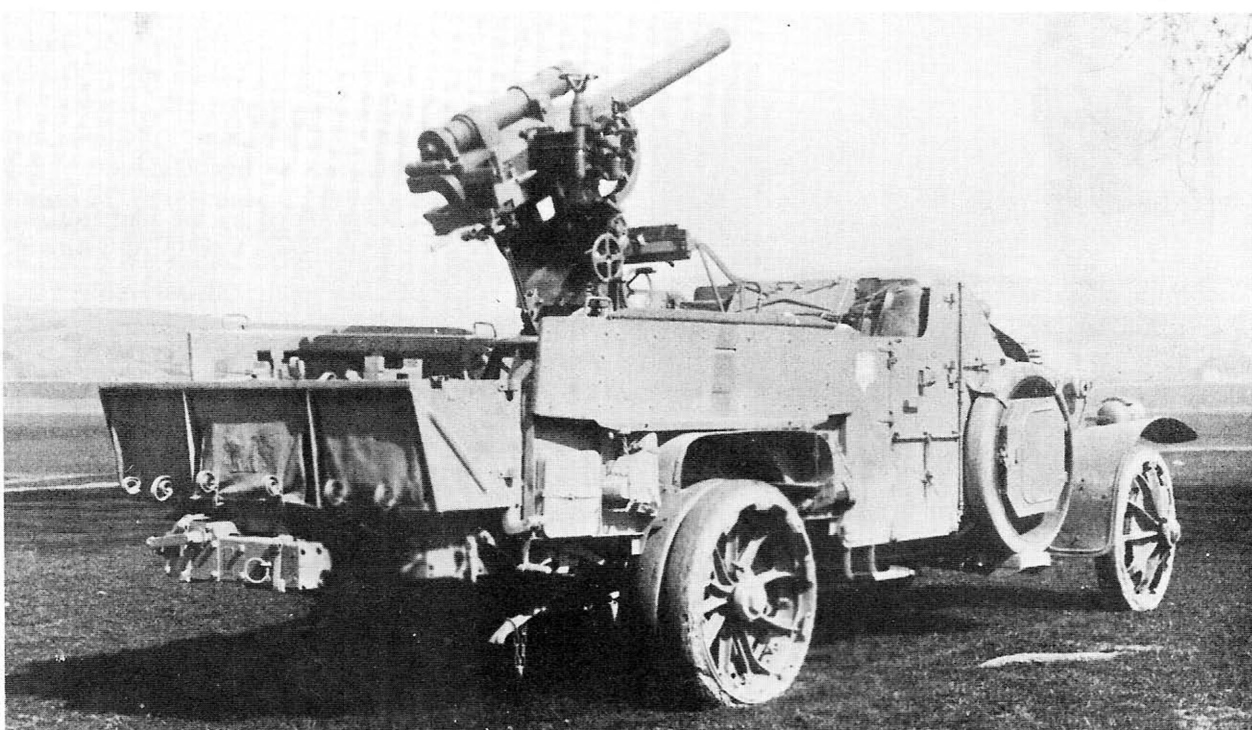
The Daimler-Benz, 1914 model, platform truck, shown mounting a 7.7 cm, M 1914, Krupp Anti-Balloon Cannon.





▲ Daimler's 1914 Platform Truck, also designated Motor Vehicle 14, fifty-seven of which were built. The photo shows the vehicle, without armament.

Daimler Motor Vehicle 14, mounting a 7.7 cm, L/27 Anti-Balloon Cannon. This was the standard vehicle of the German Anti-Aircraft Artillery during the First World War. ▼



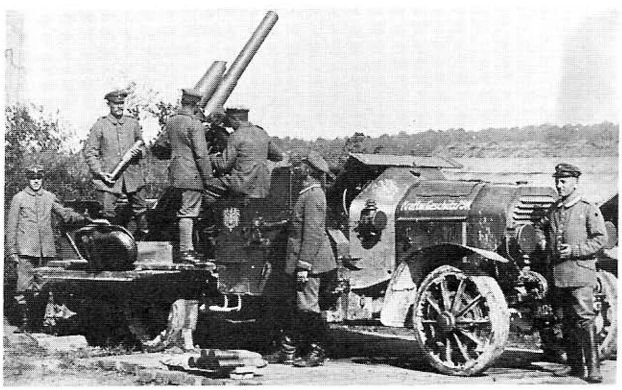
2. World War I 1914 to 1918

In 1914 the Prussian War Ministry ordered that the air defense batteries were required to

> "Prevent enemy aircraft from carrying out any tactical, strategic aerial surveillance or artillery observation missions. Furthermore, they were also to protect all important military buildings and installations along both the forward and immediate rear areas of the front line."

At the beginning of World War I, the German Army were only able to field six motorised and twelve horse-drawn Anti-Balloon Cannon, of varying calibers which they had at their disposal.

However, in 1914 to rectify this situation the Prussian War Ministry placed orders for over a hundred motorised Anti-Balloon Cannon with the Krupp and Ehrhardt Companies. Whereby, in 1914/15 Krupp and Daimler jointly, delivered a total of fifty-seven of their Anti-Balloon Cannon Trucks, then designated "Motor Vehicle 14." These vehicles differing only slightly when compared to their predecessors and had a total weight of 8 tons.



Krupp-Daimler Motor Vehicle 14. complete with 7.7 cm, L/27 Anti-Balloon Cannon.

A Motor Vehicle 14, produced by the Ehrhardt Co., mounting a light 7.7 cm, L/27, C/1914 Anti-Aircraft, Cannon from Rheinmetall.

From the Spring of 1917, onwards, Austria-Hungary was equipped with six batteries of Ehrhardt, Type 14 Platform-Trucks. Their four-wheel drives were built in accordance to patents held by Austro-Daimler.

Because of the ever growing numbers of aircraft and observation balloons the enemy were able to field as the war progressed, there were never adequate numbers of these trucks available for deployment.

In order to master this continually increasing aerial threat, a rapid expansion of air defense took place. In 1916, the Prussian War Ministry ordered that the designation, Anti-Balloon Cannon be dropped, replacing it with Anti-Aircraft Cannon (Flak). Air defense batteries were also issued with range finders, acoustic detectors and various sized search-lights. The latter to enable the troops to engage aerial targets during the hours of darkness.

The truck mounted anti-aricraft guns proved themselves as being effective against the first tanks encountered. In November 1917, near the town of Cambrai, fifty-two British tanks were destroyed by anti-aircraft gun fire. Also in 1917, motivated by the already mentioned build-up of enemy aircraft, the troops repeated and re-stressed their demands that the existing platform truck should be developed further and its performance improved. In response to these demands Ehrhardt lengthened the vehicles chassis and increased the output of the engine to 80 HP. For trials purposes a newly developed, lightweight, Henschel, 7.62 cm caliber Anti-Aircraft Gun, the L/35.5, 1918 Model was mounted on an Ehrhardt Platform Truck. Field-of-elevation of this weapon was 0° to +70°, its rate-of-fire 15 rounds per minute.

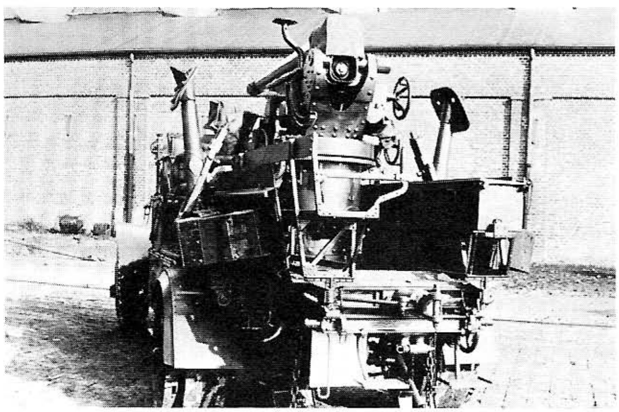
With a muzzle velocity of 590 m/s and a shell weighing 6.85 kg, a range of 9.5 km was achieved. Ceiling altitude when fired was 6.5 km. Under contract to Krupp, Daimler developed a new type of vehicle, designated the Krupp-Daimler I (KD I), which incorporated much of the experience learned from the 7.7 cm caliber anti-aircraft cannon. The official designation for this vehicle was: Tractor Mounted Anti-Aircraft Cannon, Krupp-Daimler, 100 HP. This same tractor was used by the heavy artillery batteries for towing the 15 cm, long barrelled field pieces. Under an order numbered 514.9.18 A III/6 issued by the Weapon and Ammunition Procurement Agency (Wumba) and dated September 19th, 1918, the same vehicle was to be deployed as an Anti-Aircraft Gun Carrier. In all the order called for delivery of two hundred and forty vehicles. As early as November 1918, a prototype vehicle was made available and by the time the war ended, Daimler, Stuttgart-Untertürkheim, had delivered a total of sixty-three vehicles to various units. It was planned to develop a standard design for use of the light 7.7 cm, L/27 Anti-Aircraft Gun, trials were conducted mounting the 7.62 cm, L/31.5 Anti-Aircraft Gun (Flak 18). The vehicles official designation was "Motor

From 1917 onwards, Austria-Hungary equipped six Flak batteries with Ehrhardt vehicles, their four-wheel drives were based upon patents held by Austro-Daimler.

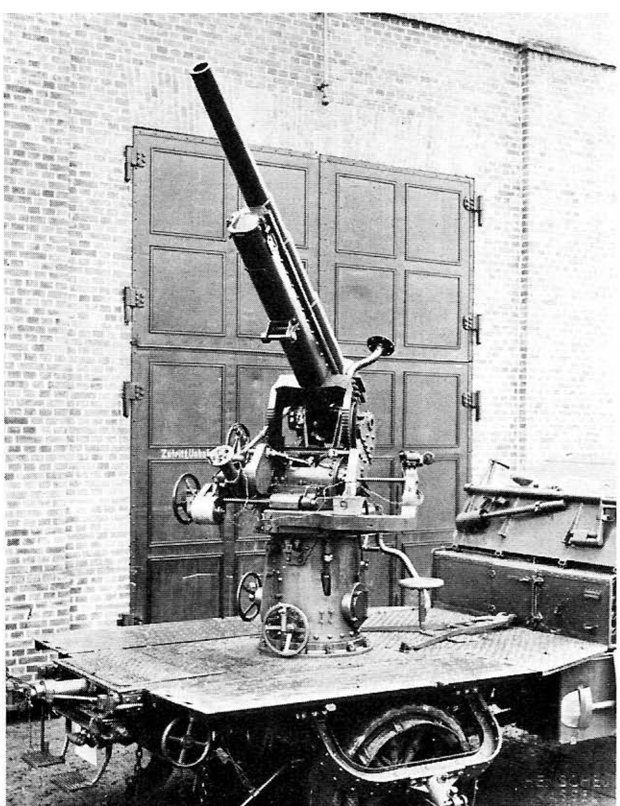
Vehicle 19", although other authentic documents describe it as a "Gun carrier". After the war had ended most of these vehicles were destroyed according to the terms of the Treaty of Versailles.

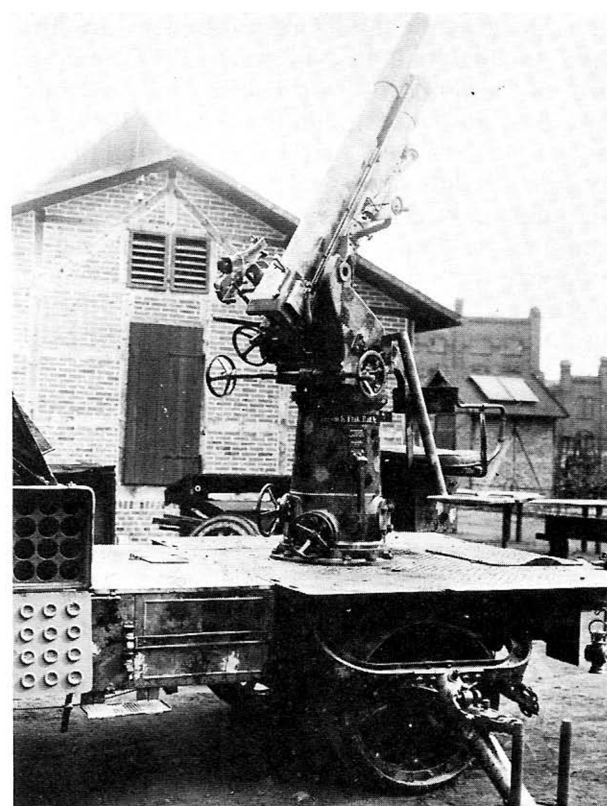
Separation of Anti-Aircraft Artillery as an individual entity from conventional Artillery and which had only taken place as recently as 1916 was also forbidden by this treaty.

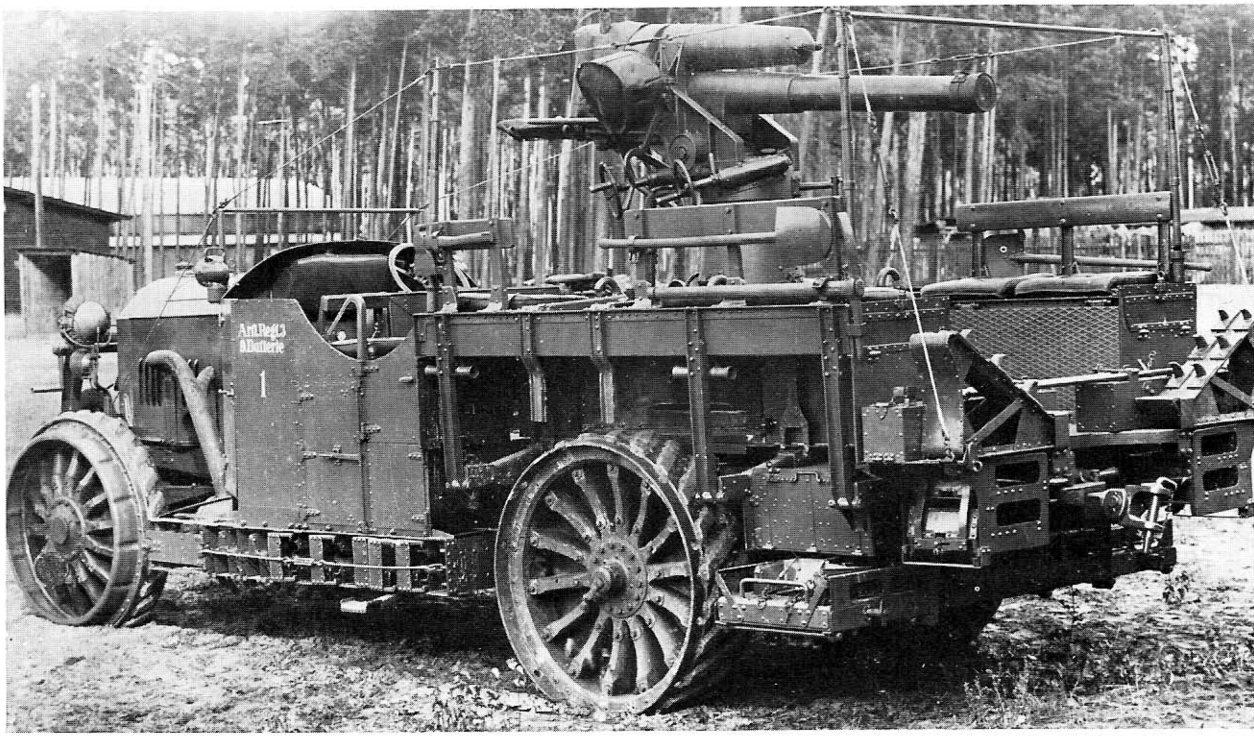
By wars end both at home and on the front there were almost two thousand six hundred anti-aircraft guns of the following assorted calibers (in cm) 2, 3.7, 5, 6.5, 7.5, 7.62, 7.7, 8, 8.8, 9, 10, 10.5.



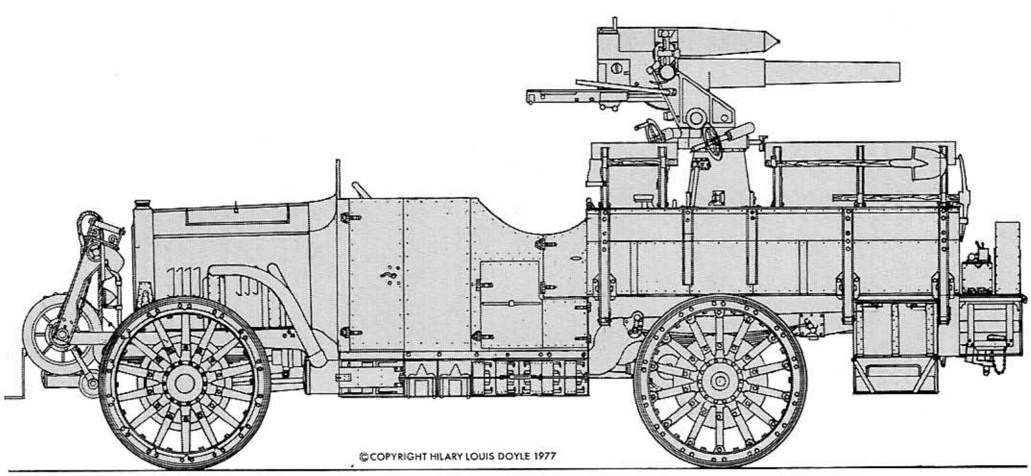
For trials purposes, in 1918 the Henschel Co. mounted the new 7.62 cm, mobile, Anti-Aircraft Cannon 18 on Ehrhardt Platform Trucks.







Shortly before the end of World War I in 1918, prototypes of the newly developed, self-propelled Anti-Aircraft Cannon (Flak-Selbstträger) mounted on Krupp-Daimler Tractor Chassis were deployed for the first time. By the time hostilities ceased Daimler had delivered sixty-three of these vehicles, most of which were to be destroyed under the Armistice Agreement. These systems all mounted a 7.7 cm, anti-aircraft gun produced by Krupp. These vehicles were fitted with steel-rimmed wheels.



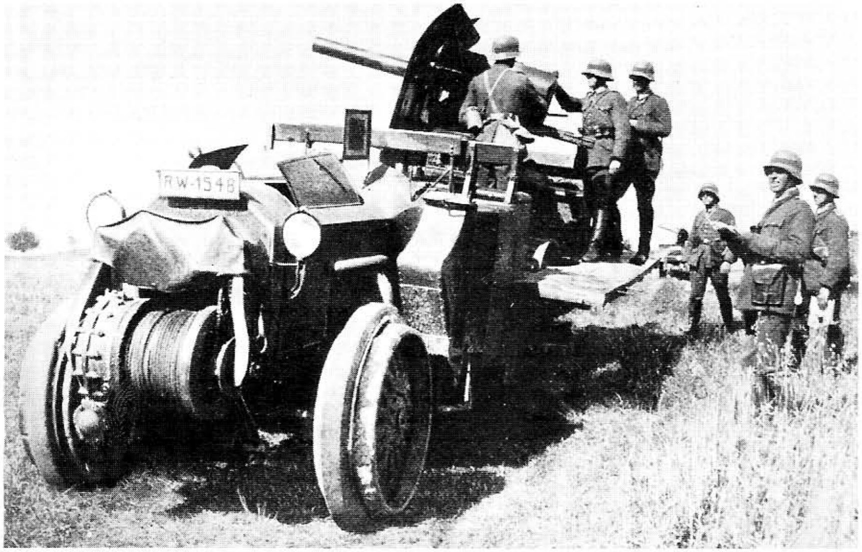
The 7.7 cm Anti-Aircraft Cannon, mounted on a Motor Vehicle 19 (Krupp-Daimler).

3. The German Reichswehr 1920 to 1935

Only a few of the self-propelled guns left over from World War I were taken over by the Reichswehr. There were various reasons for this, these were mainly that it was made impossible to fire them at their higher elevations, inhibiting locks having been fitted to prevent their being used against aircraft. Besides which the laying gear for these weapons had also been removed, both these measures being in accordance with the terms of the Treaty of Versailles. However, in 1919 and later between 1924 and 1930, there were in all, forty-nine, self-propelled anti-aircraft guns built for the Reichswehr, by Krupp-Daimler. From 1924 onwards the old iron-type tires were replaced by tires of solid rubber. Both front and rear wheels were now of the same diameter, the vehicles complete weight, including nine-man crew was 11,250 kg. A four-cylinder, type M 1574, petrol engine producing 100 HP, gave the vehicle a maximum road speed of 35 km/h. The relevant "Service Manual 600" (issued on November 9th, 1935) indicates the vehicle designation as "Motor Vehicle 19" (KW 19), defining it more specifically as an ordnance special vehicle or tractor Nr. 1 (Sd. Kfz. Nr. 1 = Special Vehicle No. 1).

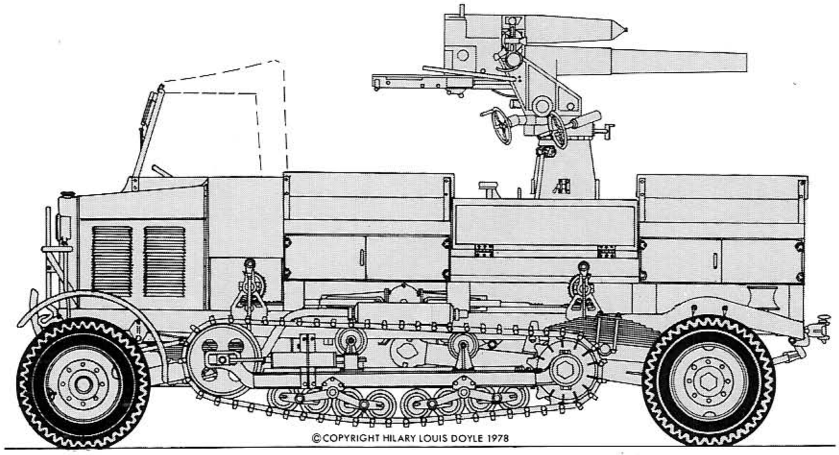
Introduction of even larger calibers of ordnance into Anti-Aircraft Artillery service and the associated weigth increases necessitated automotive engineers to re-assess the basic conception of vehicle design and construction. These newer, heavier weapons were mounted on trailer type gun carriages and towed by special artillery tractors (Art. Kr. Zug, later Flak. Kr. Zgm.) = (Artillery Motor Tractor, later Anti-Aircraft Gun, Motor Tractor).

At a conference in the Army Procurement Office/ Wa-Prüf 6 on March 14th, 1928 it was decided that new artillery vehicles had to be procured, using financial resources which the Inspectorate 6 had at their disposal. The first motorisation program which had been considered by the German Reichswehr, as early as 1926, had foreseen amongst other needs, the provision of a heavy self-

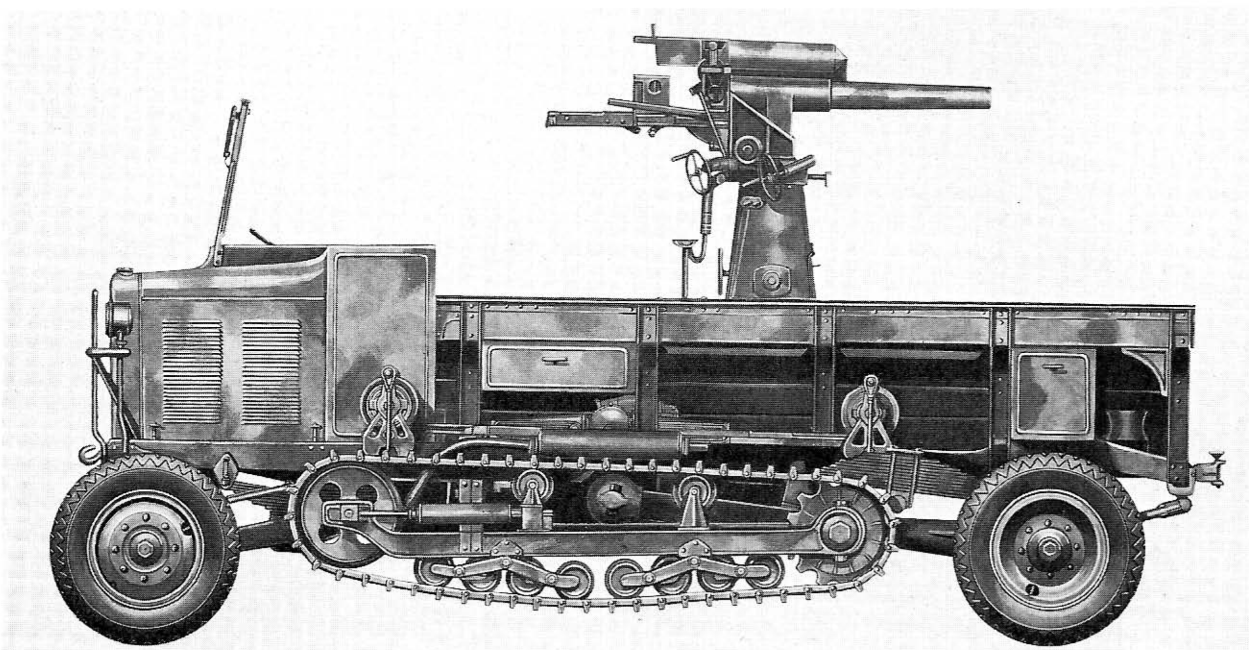


Motor Vehicle 19 from World War I were used as self-propelled, mobile artillery mounts by the German Reichswehr, anti-aircraft ordnance not being allowed to them under the terms of the Treaty of Versailles. Their steel-rimmed wheels were replaced by solid rubber tires.

The 7.7 cm Anti-Aircraft Cannon mounted on the wheel – cum-tracked tractor chassis (Krupp/Maffei)

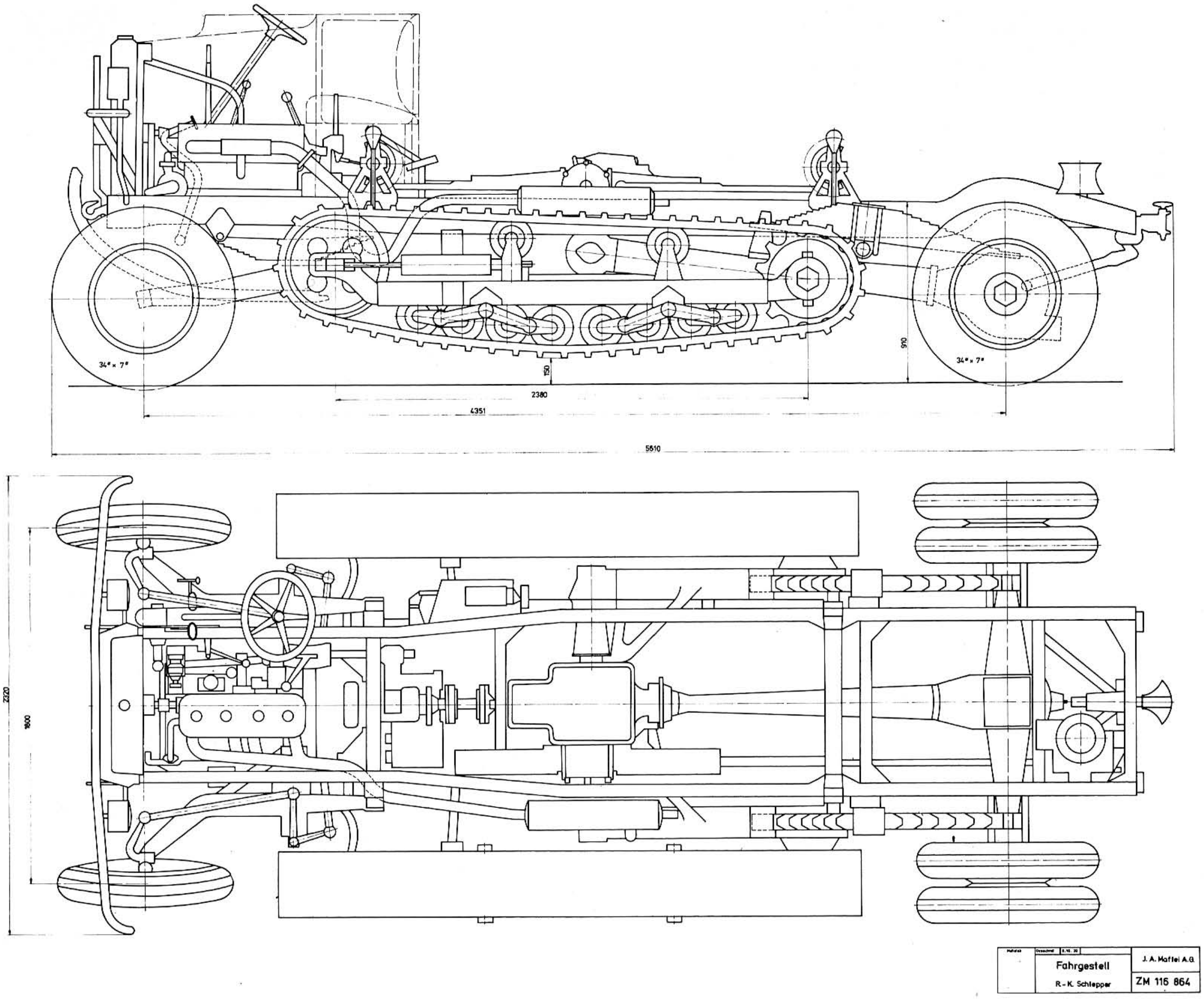


As replacements for the Motor Vehicle 19, the German Reichswehr attempted to introduce wheel-cum-track vehicles into service. These were intended to use their wheels for travelling on roads, their tracks for crosscountry operations. As the characteristics of each alternate system proved unsatisfactory, development was dropped in favor of half-tracked vehicles. Both the outline drawing and photograph (page 28) show the wheel-cum-track tractor developed by J.A. Maffei, Munich.



propelled gun carrier for use as light motorised anti-aircraft artillery, intended for replacement of the now obsolete "Motor Vehicle 19".

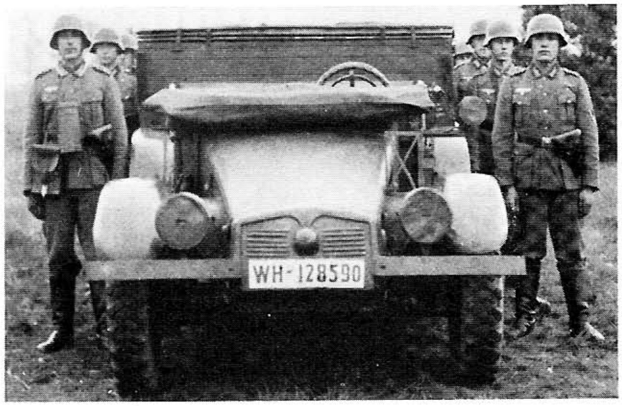
It was during these years that companies such as Dürkopp-Bielefeld, Krupp-Essen and J.A. Maffei of Munich, designed and built prototypes of wheeled and tracked tractors, with wheel-cum-track running gears. These vehicles used rubber tired wheels whilst travelling on roads and highways, bringing their tracked running gears into play for cross-country operations. Further development of these types of vehicle were soon discontinued as they were unable to meet either the road or cross-country requirements which had been specified. The Army Office/Wa Prüf 6 recommended the introduction of half-tracked vehicles into service.


34" × 7"
34" × 7"
150
910
2380
4351
5610
2320
1800
Fahrgestell
R.-K. Schlepper
J. A. Maffei A.G.
ZM 116 864

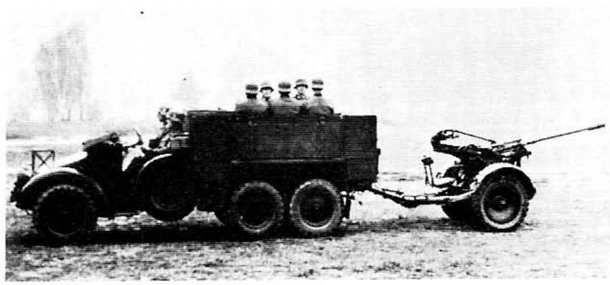
4. The German Wehrmacht 1935 to 1945

The Reichswehr had in the preceding years designed many of their own motor vehicles, after which orders for constructing prototypes were placed with industry. Punctual manufacture of these prototypes, particularly during the Wehrmacht's expansion, was often accompanied by subtle applications of official pressure. Developement of wheeled, self-propelled air defense vehicles, however had almost come to a complete standstill.

Contrary to the restrictions imposed by the terms of the Treaty of Versailles, initial trails of the 8.8 cm caliber, Type 18, Anti-Aircraft Guns (Flak 18) were carried out during 1930–31. Directives for these trials originating from the Wa Prüf 4 (Weapon Tests 4) Department of the Army Ordnance Office. Many of the trials included and were based upon experiences of the last years of World War I. None of these proven weapons were issued to field units however until 1933. In order to circumvent the pertinent clauses of the Versailles Treaty, the Army fitted all newly developed weapons with type-plates indicating their original commission into service as early as 1918. The 8.8 cm Type 18 Anti-Aircraft guns were cruciform mounted, they were transported upon special, two-piece gun-limbers and towed using either three-axled multi-purpose trucks or eight ton half-tracks. With a muzzle velocity of 820 m/s, maximum range was 14,860 meters, firing altitude ceiling being 10,600 meters. The 8.8 cm Anti-Aircraft guns very soon became the standard ordnance for air defense units. However the transport units (Fahrabteilungen) and motorised batteries (Kraftwagen Batterien) were taken over from the Army by the Air Force in 1935, they were then re-grouped into Anti-Aircraft Battalions. In all they now made up a total of fifteen heavy and three light, motorised battalions. From this time onwards the Reich Air Ministry's Ordnance Master General, Air Defense Department, assumed complete control of all developments, production and organisation of Air Defense.* In 1936, the Army once again began organising its own air defense units.



The Krupp L 3 H 163 cross-country truck was used for towing the 2 cm Flak 30 cannon, mounted on its special, type 104 trailer. The photographs show the vehicle crew lined-up alongside the vehicle and mounted.



Already in 1931, a 2 cm caliber, fully-automatic, recoil-operated – toggle locking, machine cannon,

*Ordnance Master General of the Air Force (Generalluftfeldzeugmeister) from February 1938 until November 1941, was Col. General Udet, who had, from early 1936 previously been head of the Technology Office, his later successor Fieldmarshal Milch taking over in 1941.

During World War II, 2 cm Flak cannon were occasionally hoisted aboard individual vehicles, providing make-shift self-propelled mount.

designed by Rheinmetall, being manufactured by the Solothurn Co. was in service with the troops. This weapon was designated the 2 cm – Anti-Aircraft Cannon – 30 (2 cm Flak 30). To facilitate its being towed this weapon had a triangular cradle dimensioned to suit transportation on the single axled, type 51, Special Trailer (Sonderanhänger 51). Besides the 2 cm cannon, troops were issued in 1933–34 with limited numbers of 3.7 cm caliber, type 18, Anti-Aircraft Guns (3.7 cm Flak 18), carried on the dual-axled, type 104 Special Trailers. This was a recoil-operated weapon with centrally locking breech, mounted on a transverse cradle. Firing cadence was 150 rds/m, its shells were fitted with self-destructive fuses activated after travelling 3,500 meters.

All Anti-Aircraft Artillery, was now fully motorised as all the guns were towable, self-propelled mounts being the exception.

By increasing the caliber to 3.7 cm the effectiveness of each individual shell at the target was improved, firing cadence however, reduced.

Although the hit probability of the 2 cm and the 3.7 cm caliber weapons was the same, the higher cadence of the 2 cm cannon provided gunners with the chance of scoring more hits from bursts of fire.

In 1939, the German Wehrmacht had by far the most powerful air defense capability in the world. The Luftwaffe had at their disposal twelve hundred, heavy, medium and light anti-aircraft batteries plus a further one hundred and eighty searchlight batteries.

As the Anti-Aircraft Artillery of the Luftwaffe was having to be more extensively deployed for defending the Reich, the Army requirements for qualified and increased aerial protection for the troops could not be met. Therefore, on February 1st, 1941 an Army Anti-Aircraft Inspectorate, Inspectorate 13 was established within the Army High Command. The parent arm for this new branch being the Artillery.

Of the thirty Army Anti-Aircraft Artillery Units planned to establish, ten were existing by June 1st 1941. These were placed exclusively under the command of the armored divisions.

During World War II, as the Allies aerial superiority increased, air defense by the German Wehrmacht also assumend more importance.

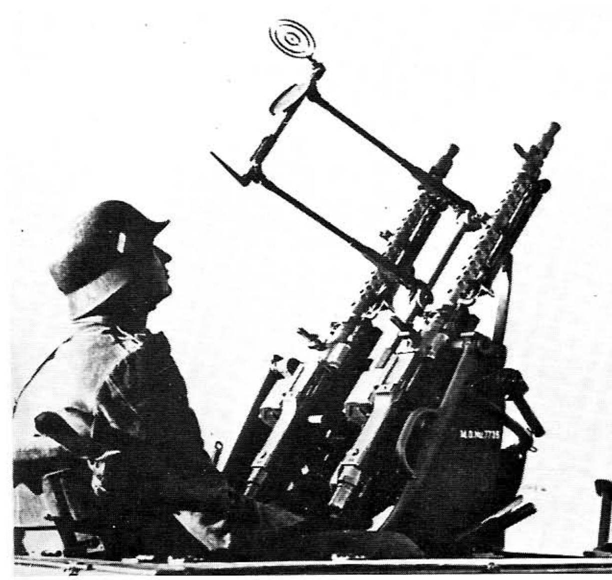
Both anti-aircraft tanks and self-propelled A-A guns were now being developed which utilised chassis of armored vehicles which were currently in service and still manufactured in quantity. Provision of air defense for reconnaissance units in the field was established by mounting A-A guns on scout cars (dual-purpose weapons).

Table 1:
Rates of fire and Ammunition for Anti-Aircraft Guns in Service at this Time

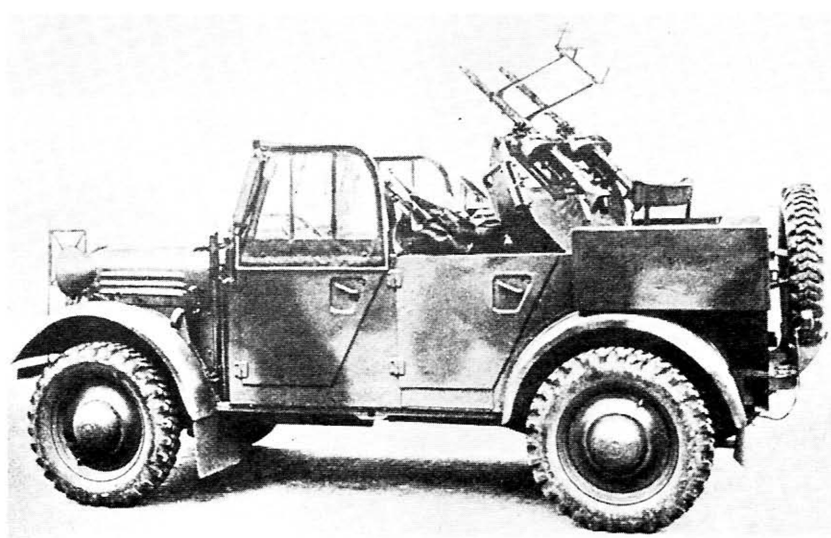
	2 cm Flak 30	2 cm Flak 38	3.7 cm Flak 36	3.7 cm Flak 43
Cadence, Theoretical Rounds-per-min.	280	450	180	200
Cadence, Practical Rounds-per-min.	120	220	120	120
Shell Weight in gr. (explosive warhead)	132	132	623	623
Explosive Charge in gr.	6.2	6.2	26.5	26.5

4.1 Unarmored Wheeled Vehicles as Anti-Aircraft Gun Carriers

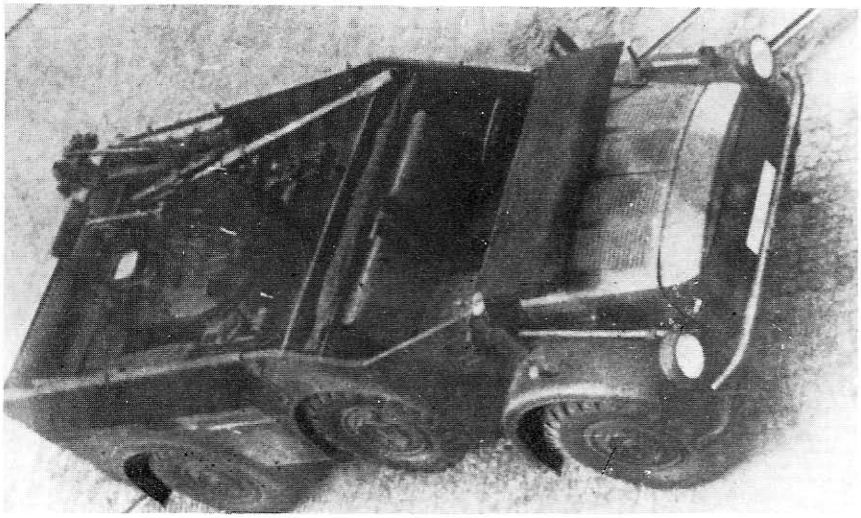
Intitially, the question of mounting either the 2 cm or 3.7 cm caliber AA-weapons on anything other than fully or half-tracked vehicles had been hardly given any consideration. The exception being a very small quantity of self-propelled guns. In order to provide some air defense for motorised troop units a twin co-axial mount for two MG 34 machine guns had been developed and was mounted on the Daimler-Benz General-Purpose Jeep (Kübelwagen). By 1936 this vehicle was succeeded by a standard, light, jeep type vehicle, the Kfz 4 (Vehicle 4), the co-axial mount however remained in use. The series produced, 2 cm Flak 30 weapon, mounted on the standard chassis of the heavy, passenger vehicle (Kfz 70) was extended by a wide variety of alternatives during the course of World War II. A further self-propelled vehicle, the all-wheel drive, 4.5 t trucks built by both Büssing-NAG and Daimler-Benz were armed with either, quadruple 2 cm weapons or alternatively 3.7 cm or 5 cm caliber weapons, in most cases the engine hood and drivers cab were lightly armored.



▲
For non-mechanised troops, the German Wehrmacht developed, air defense escort vehicles, either horse drawn or motorized. The photo to the right shows a twin-anti-aircraft, type 34 machine-gun installation from a horse drawn unit. The photo above documents the first attempt to mount the same twin-machine guns on a medium class jeep.



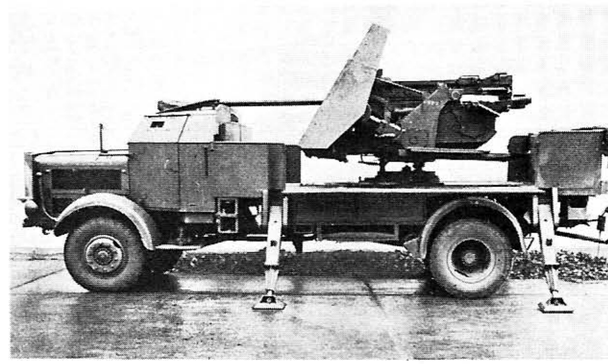
The Standard Air Defense Escort Vehicle (Kfz 4) based upon the chassis of the light, Standard passenger car was produced in considerable quantity. ▶



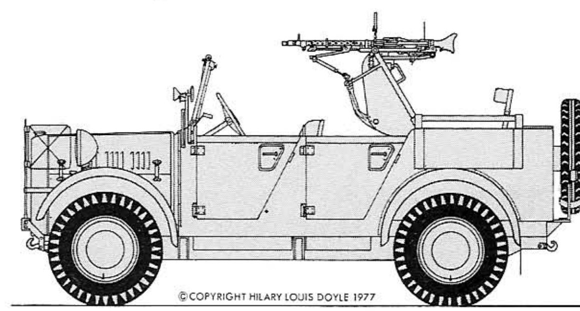
This general purpose, air defense escort vehicle (Kfz 70) was deployed by both Army and Air Force Units.

A heavy, standard passenger car, serving as a make-shift mount for a 2 cm, Flak 38 cannon.

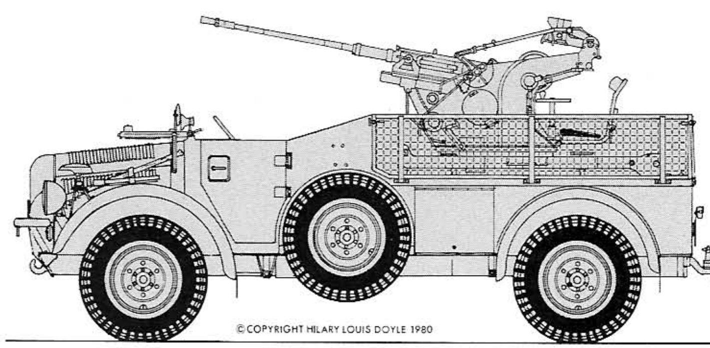
During World War II, continual provisional solutions were developed in order to improve air defense, many of these systems also proved capable of successful deployment against ground targets. The photographs show both 2 cm and 3.7 cm Flak cannon mounted on three ton, cross-country Opel, Type 6700 A trucks. Practically every suitable carrier vehicle was used in this way at one time or another. ▼



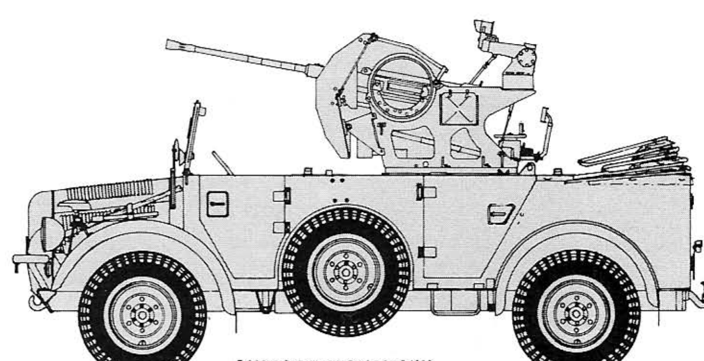
In considerable numbers, the four-wheel drive, 4.5 ton trucks, complete with auxiliary armor protection, from the "Schell-Program" were deployed as self-propelled "Flak" gun-carriages. Both photographs show a Daimler-Benz, L 4500 A truck, the left-hand picture showing a 3.7 cm Flak mounted, the right a 5 cm Flak.



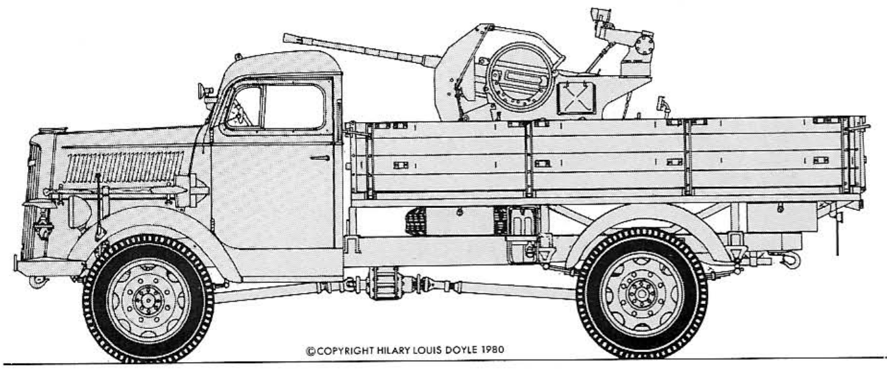
General Purpose Air Defense Vehicle (Kfz 4)



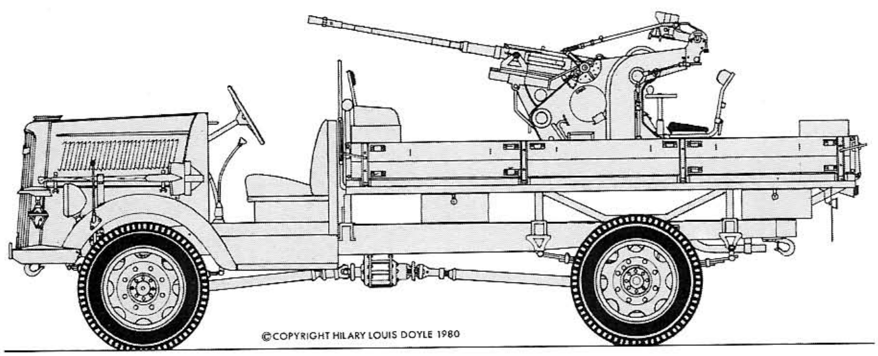
General Purpose Air Defense Vehicle (Kfz 70)



Standard, Heavy Passenger Vehicle mounting a 2 cm Flak 38

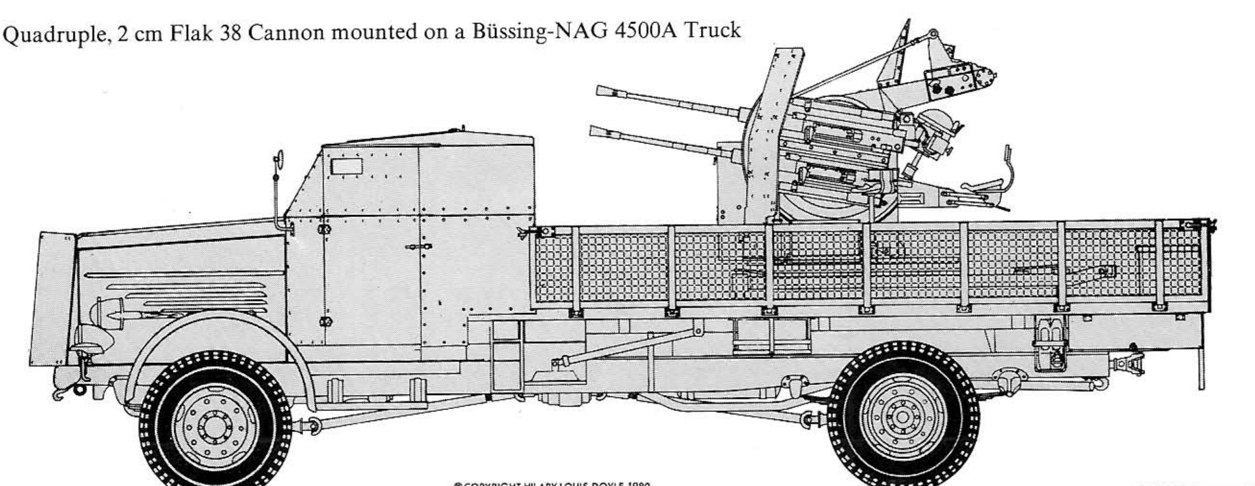


2 cm Flak 38 Cannon mounted on an Opel, 6700 A, truck

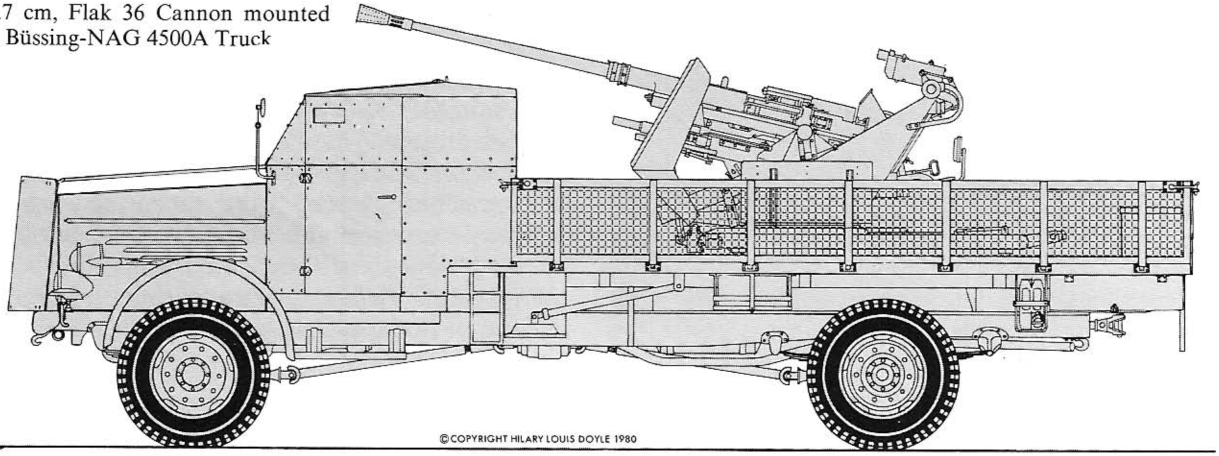


General Purpose Troop Air Defense Vehicle, 2 cm Flak 30 Cannon mounted on an Opel 6700A truck

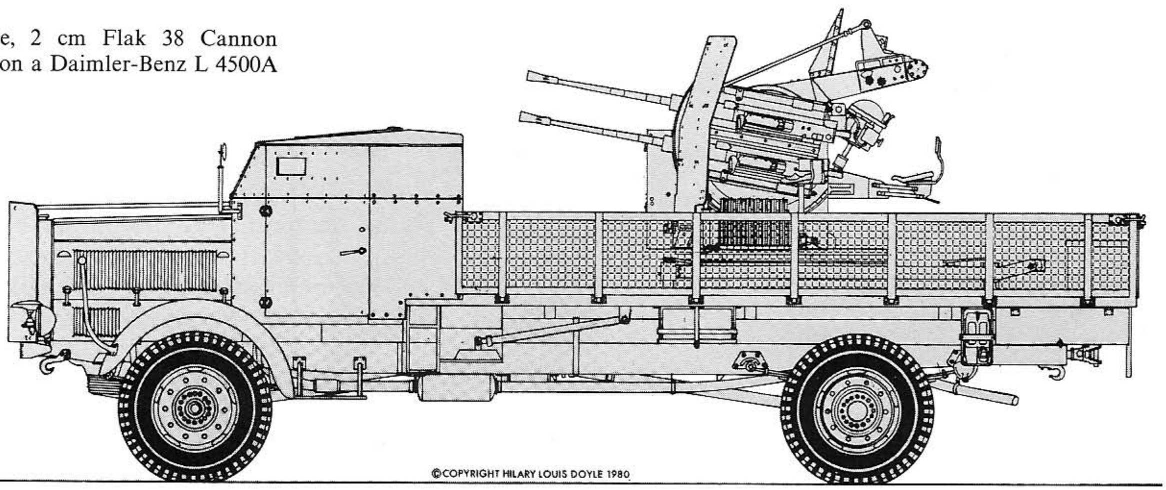
Quadruple, 2 cm Flak 38 Cannon mounted on a Büssing-NAG 4500A Truck



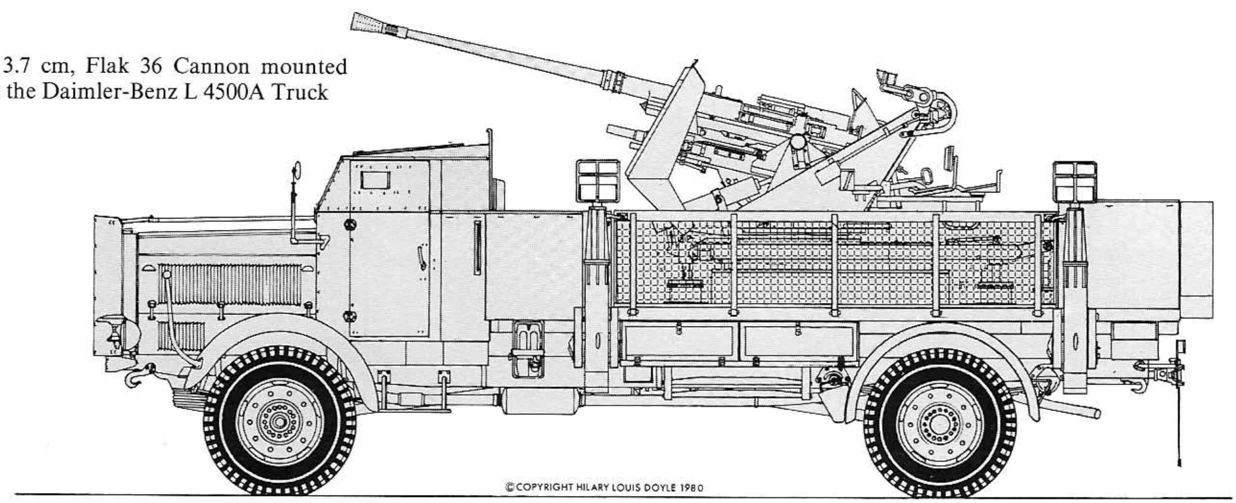
A 3.7 cm, Flak 36 Cannon mounted on a Büssing-NAG 4500A Truck



Quadruple, 2 cm Flak 38 Cannon mounted on a Daimler-Benz L 4500A Truck



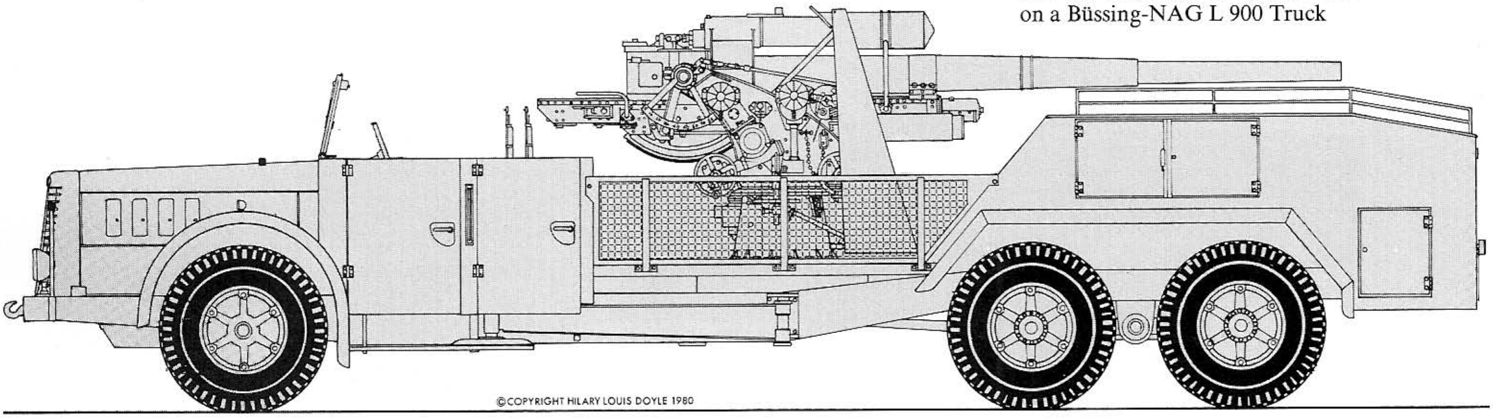
A 3.7 cm, Flak 36 Cannon mounted on the Daimler-Benz L 4500A Truck



4.1.1 8.8 cm Anti-Aircraft Gun "Flak 18" Mounted on a Büssing-NAG, 6 × 4 truck chassis

In 1943, some of the aging, practically obsolete, 6×4 wheeled, Tank Transporters from the former "Light Divisions" were re-commissioned for conversion to self-propelled gun carriages suitable for mounting the 8.8 cm caliber – Flak 18 – guns. These trucks had originally been built to transport the type I and II Armored Fighting Vehicles. Their type designation was Büssing-NAG L 900. When mounting their new 8.8 cm ordnance they were suitable for deployment against both air and ground targets. These vehicles were additionally fitted with "outrigger" type stabilisers for steadying the vehicle during firing, the suspension then had no detrimental affect on gunnery accuracy. As late as 1945, two of these converted vehicles were used against ground targets during the German defense of Budapest.

A Büssing-NAG six-wheeled, type L 900 truck, used as a self-propelled carrier vehicle for the 8.8 cm Flak 18 Cannon. Very few of these vehicles were converted from the tank transporters of the former light armored divisions.



The 8.8 cm, Flak 18 Cannon mounted on a Büssing-NAG L 900 Truck

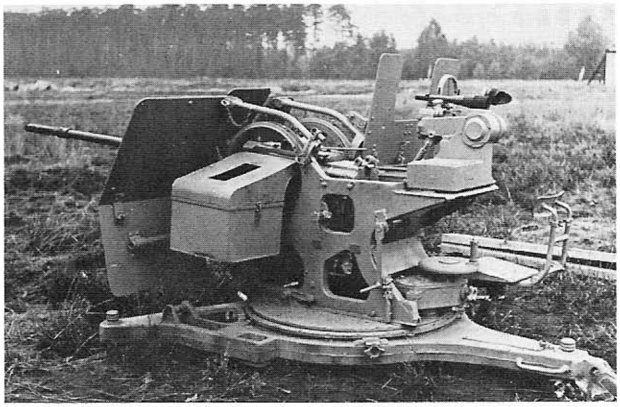
4.1.2 3 cm-Flak 103/38 Mounted on a Steyr Truck

On December 21st 1944 the Army Ordnance Office, Dept. Wa I Rü (WuG 2) placed the Order No. 1-0172-7061-44 with Gustloff-Werke, an armaments factory in Suhl/Thüringen. This order called for the delivery of one thousand 3 cm Flak 103/38 gun carriages. Rheinmetall-Borsig Werke in Guben were to manufacture the necessary 3 cm weapons for these mounts, delivery was completed by March 1945.

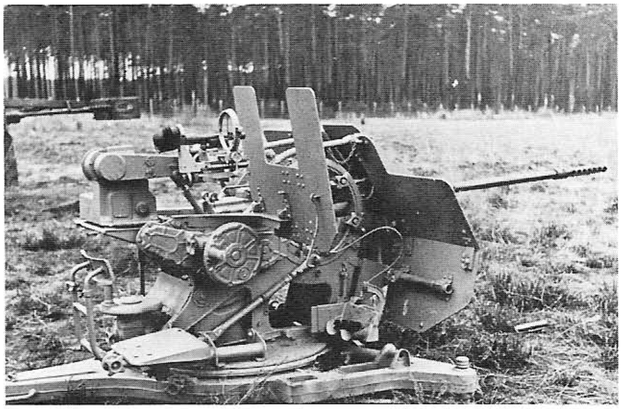
Minutes taken at a meeting at the Gaubschat Vehicle Factory, Berlin-Neukölln on December 11th, 1945 read, that in order to reinforce air defense, both the 2 cm Flak 38 and 3 cm Flak 103/38 would be introduced into service as self-propelled weapons. To do this it was intended to mount them on the chassis of the Standard Steyr 2 ton truck (4×4).

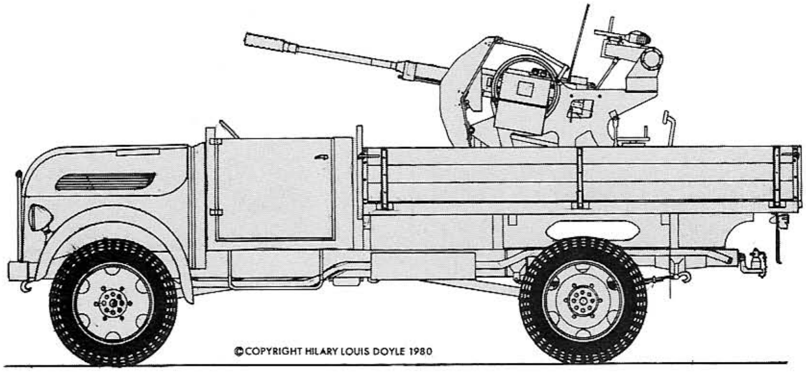
In the interim period, regular 2 t Steyr trucks would be employed as temporary gun carriers. This makeshift solution was supposed to fill the gap, till the final solution was available for carrying the 2 cm and 3 cm weapons.

The Gaubschat Co. were charged with the responsibilities for both designing and producing the new vehicle. As it was necessary to adapt the vehicle's open superstructure to suit the weapon, an easily fitted kit for this and for bunkering the ammunition was requested. Both of the load retain-



For the makeshift Solution, 3 cm Flak 103/38, known as the "Fighter Bomber Scarer" (Jaboschreck) orders for one thousand units had been placed by the end of 1944. These weapons were to be mobilised by mounting them on the Steyr 2000 A cross-country truck. The photographs show both sides of the 3 cm Flak 103/38 fitted on the mount of the 2 cm Flak 38 weapon.





3 cm Flak 103/38 "Fighter Bomber Scarer" mounted on a Steyr 2000A Truck

ing truck bed side panels were cut-out to facilitate operating the gun. Two boxes were mounted to the left and right hand outer face of the tailboard, these were used for stowing spare gun barrels. Two spindles for blocking the vehicles suspension when firing were also fitted. Holes cut in the secondary platform decking served as stowage bunkers for fourteen, type 30 ammunition boxes, holding a total of 560 rounds.

A prototype vehicle was made available to the Vehicle and Tank Testing Facility in Kummersdorf, on December 11th, 1944. Firing trials with both the 2 cm Flak 38 and the 3 cm Flak 103/38 followed on December 13th, 1944.

Pre-production engineering using a Steyr 2000 A truck, chassis No. 270.01.17008 was then begun by Gaubschat. This vehicle had neither tarpaulin frame or tarpaulin and was commissioned in service as a Troop Air Defense Truck. Some time later complete sets of production drawings and other documentation was transferred by Gaubschat to the "Ostbau-Sagan" Command in Sagan/Silesia, who as Gaubschat continued production of the vehicle until the war ended.

Attending firing trials of the 3 cm, Flak 103/38 Cannon, on October 16th, 1944 at the Verskraft Ranges, Kummersdorf were:

Lt. Gen., Dipl.-Ing.	Erich Schneider	Head of Wa Prüf, Ordnance Office
Maj. Gen., Dipl.-Ing.	Ernst Bolbrinker	Head of Inspectorate 6
Col. Dipl.-Ing.	Herbert Crohn	Army Ordnance Office, Wa Prüf 6
Col.	Grunow	Reich Air Ministry Ordnance Master General Flak Weapons
Lt. Col., Ing.	Schniederjost	Reich Air Ministry
Lt., Dipl.-Ing.	Josef von Glatter-Götz	Inspectorate 6
2nd Lt.	Ruthard Fitzner	OKH Ostbau
2nd Lt.	Graf Seherr-Thoss	OKH Ostbau
Senior Civilian Engr.	Engel	Rheinmetall-Borsig, Guben
Senior Civilian Engr.	Kuppe	Rheinmetall-Borsig, Unterlüss
Sen. Civilian Engr.	Kurt Ebel	Daimler-Benz, Berlin-Marienfelde

(In the background a wooden model of the "Ball Lightning" [Kugelblitz] Anti-aircraft Tank.)

4.1.3 British and French Trucks as Anti-Aircraft Gun Carriers

Some small numbers of British and French trucks were converted to carry the 2 cm Flak 38 Cannon by French industry. However as these vehicles had practically no cross-country capability they served no useful tactical purpose.

Some numbers of captured army trucks were converted to Anti-Aircraft System carriers. The photograph shows a Canadian produced, 30 cwt truck (Chevrolet C 30) mounting a 2 cm Flak 38 cannon.

In the latter stages of the war, more and more German Wehrmacht vehicles carried twin, roof-hatch mounted machine guns for air defense purposes. Both photographs (below) show a twin mount installation in the cab roof of a French, Citroën, Type 45 truck developed by OKH Ostbau. (Serving the weapons, Graf von Seherr-Thoss.)

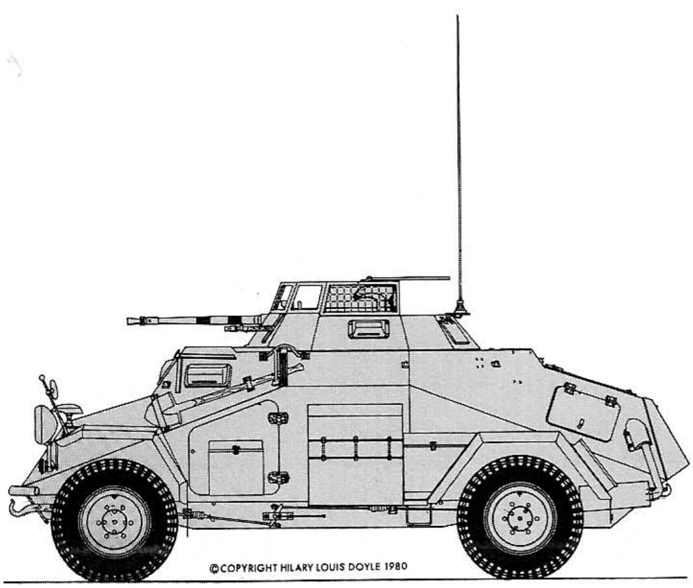
4.2 Armored Scout Cars as Anti-Aircraft Gun Carriers

4.2.1 Light, 4× 4 Armored Scout Cars

The armored car squadrons of the armored reconnaissance regiments were issued with their first new armored cars as early as 1935. Included among these vehicles was the light, armored car, 4×4, 2 cm (Sd. Kfz 222). These vehicles were intended to support and protect the radio reconnaissance scout cars in the field and were armed with both a 2 cm KwK 30 cannon and type 34 machine gun, for engaging aerial or ground targets.

Field of traverse was 360°, elevation ranging from –7° to +80°. The three-man crew was made up of a driver, commander (loader) and gunner. Both weapons were mounted on a common socket-mount which was bolted to each side of the chassis. This socket-mount consisted of a pedestal and rotating carrier plate, on which both the upper carriage section and cradle were mounted. Additionally the cradle served for mounting both the weapons and sight. Weapon traverse and elevation drives were manually operated. Commander and gunners seats were set upon two steel tubes anchored to the carrier plate, with a secondary fixing near the upper carriage section. A roofless turret protected the commander and gunner against ground fire up to eye-level. The armored protective shield consisted of a mantlet and carrier, traversable through 360°. The upper section of the turret was protected by a hinged, divided wire mesh cover. When engaging ground targets (at elevations between -7° and +20°) these coverparts could be opened and closed by means of rods. For aerial target engagement (elevations of +20° or more) these coverparts were raised sideways and secured with clips. Combat weight of the vehicle was 4.8 tons, including a full complement of ammunition, one hundred and eighty rounds of 2 cm cannon shells and one thousand and fifty rounds of machine gun ammunition. As the space within the turret was very cramped due to the room required by the socket-mount, on April 20th, 1940, the Army Ordnance Office, Dept. Wa Prüf 6, commissioned both the Appel Co. of Berlin-Spandau and F. Schichau Co. of Elbing, to develop a 2 cm 38 suspension mount to replace the existing socket mount 30.

Mounted upon this new gun cradle were a 2 cm KwK 38 (Fighting Vehicle Cannon) Cannon and a type 42, Machine Gun. The triggering mechanisms of which were coupled together, besides permitting both weapons being fired simultaneously, individual operation of either weapon against air or ground targets was also possible. For engaging ground targets a turret target telescopic sight (TZF 3a) was installed. Above this sight a secondary sighting device consisting of a notched back-sight, spacing rod and circular reticle, this was intended to assist rapid aiming of snap shot. With overall dimensions of 1850×1500×1250 mm, total weight of the new mount less weapons was 540 kg. Weapons field-of-elevation were –4° to +70°, traverse was a full 360°. The roofless turret could be covered by means of hinged wire mesh flaps being raised from the sides, these flaps were also fitted with rearward folding gimbals which could be locked at any desirable position, these were used

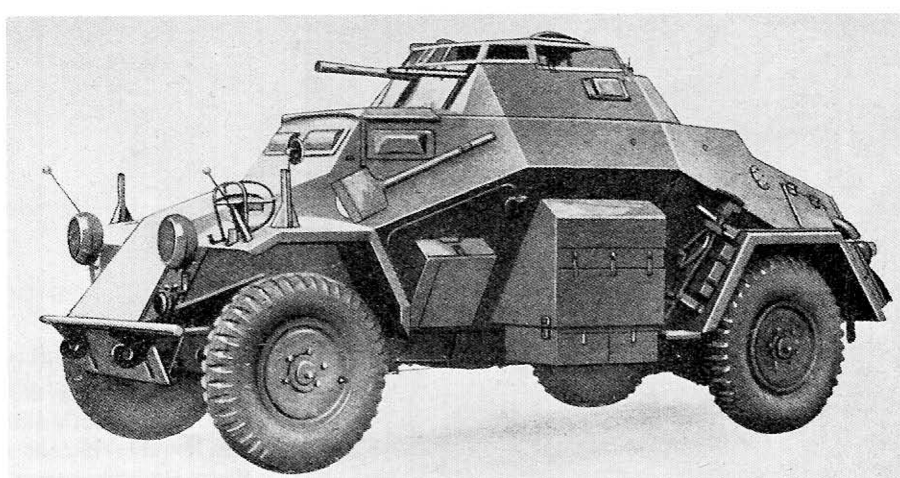


Light Armored Scout Car (2 cm) (Sd. Kfz 222)

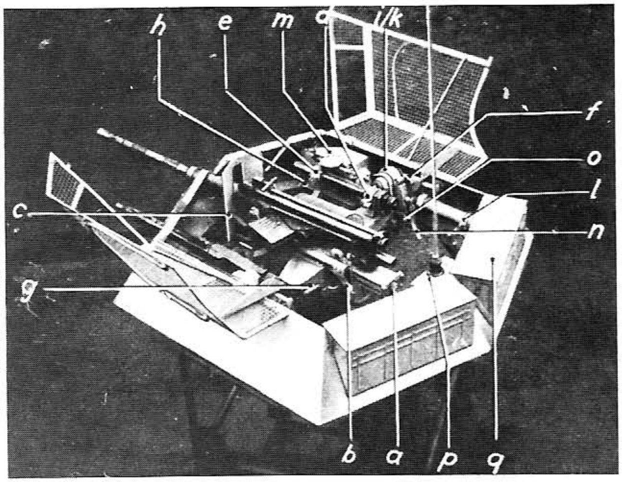
as fixtures to facilitate anchoring a tarpaulin over the fighting compartment roof. Welded to the rear of the gun mount were two tubular seat supports for carrying the adjustable seats. Radio equipment and antenna were also stowed/mounted respectively in/on the turret.

As successor to the light, armored car, according to a requirement from the Army High Command/ General Army Office/Motor Vehicle Group/Armored Troop Inspectorate (OKH/AHA/AgK/ In6), dated July 21st, 1941 a new vehicle was to be commissioned, which except for its engine, transmission, suspension and rear-hull section would be extremely similar in appearance to the eight wheeled, armored car. Its front section being protected with 30 mm thick armor plate. A rear mounted, air cooled, 125 HP Tatra diesel engine was to be installed. Wheel track widths were identical at 1950 mm. Maximum road speed of 85 km/h and combat weight of approximately 7 tons were anticipated.

By Spring of 1943, Büssing-NAG of Berlin-Oberschöneweide, had built two prototype vehicles and received subsequently an order for producing a further thousand of such vehicles. Chassis were to be built at the Horch factory of Auto-Union in Zwickau. A four man crew had available a 2 cm Fighting Vehicle (KwK 38) Cannon and the type 34 Machine Gun. Both these weapons were cradled in a suspension, type 38 gun mount. This vehicle never went into series procuction.

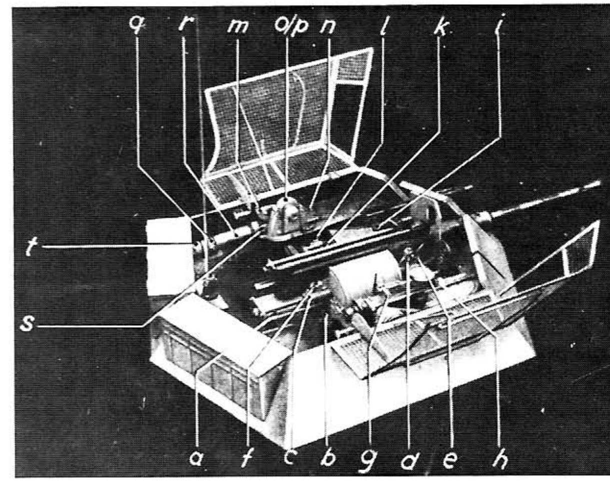


The light armored scout car (2 cm) (Sd. Kfz 222) was also used as an anti-aircraft vehicle by armored reconnaissance units. The lower photograph show the weapons in the transport position, the upper; weapons elevated for air defense.



Turret lay-out with weapons installed (viewed from the upper-left)

a Recoil Mechanism
b Bearing Arm
c Gun Shield for Vehicle Cannon 38
d Hinge Bearing
e Casing
f Compensator Segment
g Left Carrier Arm
h Right Plate
i Right Trunnion Bearing
k Right Arrester Block
l Bearing
m Gear Box Housing
n Clutch Lever
o Switch Plate
p Angle Plate
q Housing



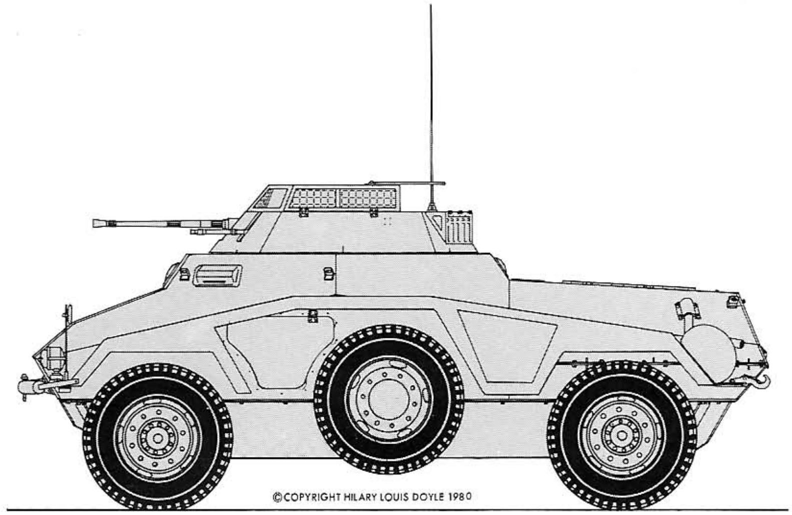
Turret lay-out with weapons installed (viewed from the upper right)

a Cradle Housing
b) Locking Catch
c Mounting Slide for Vehicle Cannon 38
d Pedestal
e Locking Pin
f Claw
g Adjuster Screw
h Setting Screw
i MG Mount
k MG Sliding Mount
l Claw
m Compensator Segment
n Left Plate
o Left Trunnion Bearing
p Left Arrester Block
q Bearing
r Spring Seat
s Push Rod
t Strut

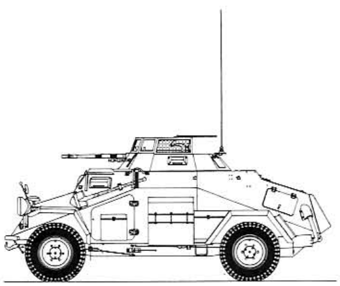
As successor to the socket-mount for armored vehicles, which used a lot of the space within the fighting compartment, a suspension mount, the model 38, was developed. The pictures show details of this mount with the 2 cm, Flak (or Combat Vehicle Cannon) 38 Cannon and MG 42 machine gun installations.

◀ It was planned to replace the light armored car, (Sd. Kfz 222) based on the chassis of the heavy Standard passenger car, with a new vehicle having an air-cooled Tatra engine. Except for the prototypes this vehicle never went into production.

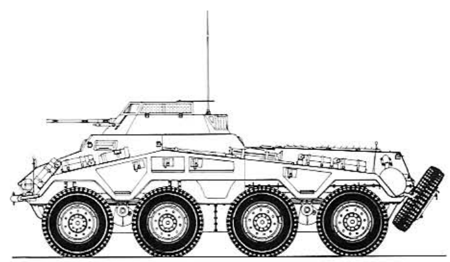
The new (2 cm) light armored car



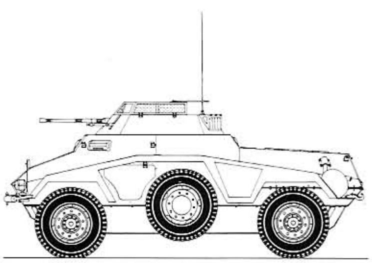
Armored Scout Car Comparisons



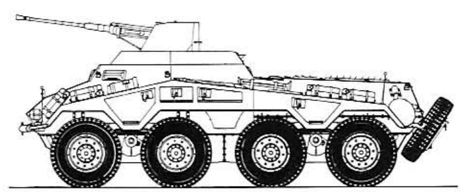
Light Scout Car (2 cm) Sd. Kfz 222)



Heavy Scout Car (2 cm) (Sd. Kfz 234/1)



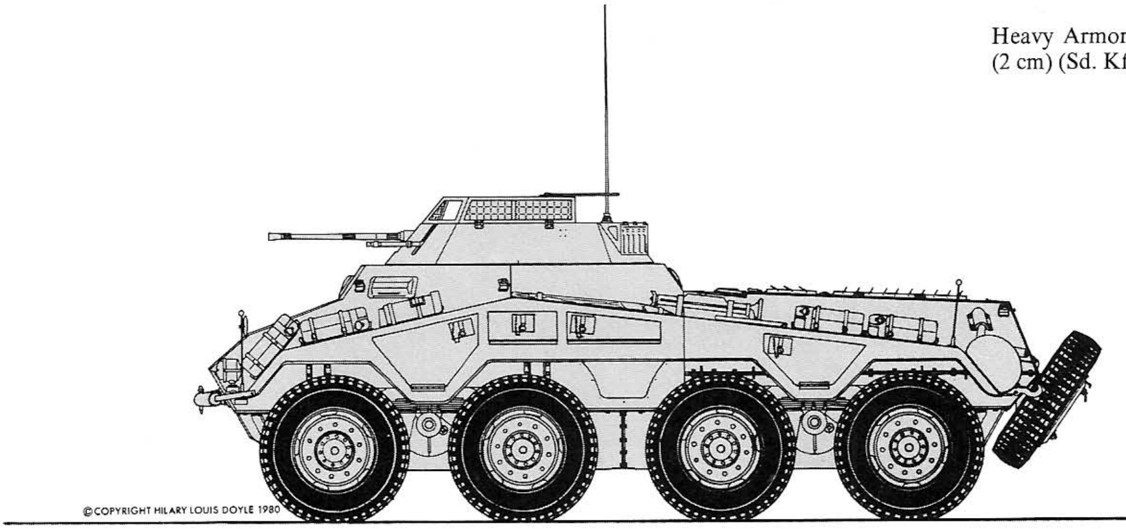
New Light Scout Car (2 cm)



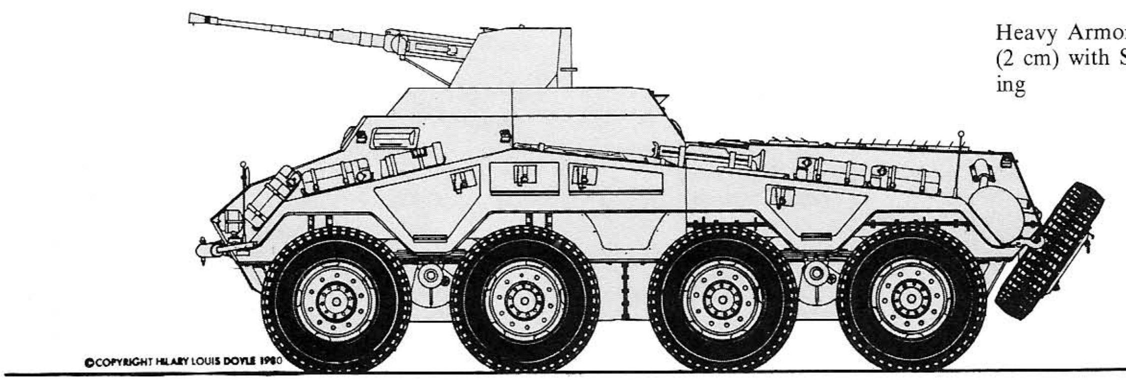
Heavy Scout Car (2 cm) Swivel Mounting

4.2.2 Heavy, 8 × 8 Armored Scout Cars

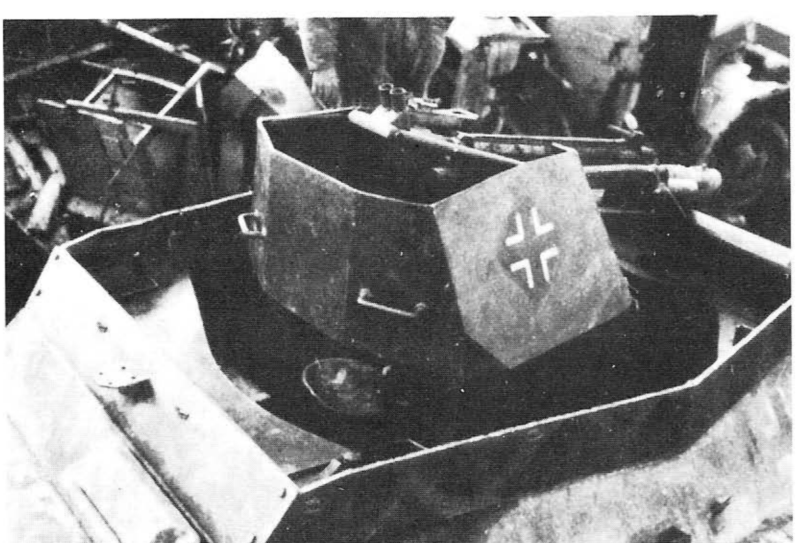
Besides its being installed in the light, armored scout car (Sd. Kfz 222) and the latters immediate successor, the suspension-mount (type 38) cannon mounting, complete with 2 cm-AFV (KwK 38) cannon and type 34 machine gun were also standard armament for the eight wheeled. (Sd. Kfz 234/1) armored cars. This vehicle weighed 11.5 tons and had a four-man crew. In 1944, this vehicle was the standard AFV used by the armored reconnaissance squadrons. Its Tatra, air-cooled, twelve cylinder engine gave the vehicle an operational range of one thousand kilometers.



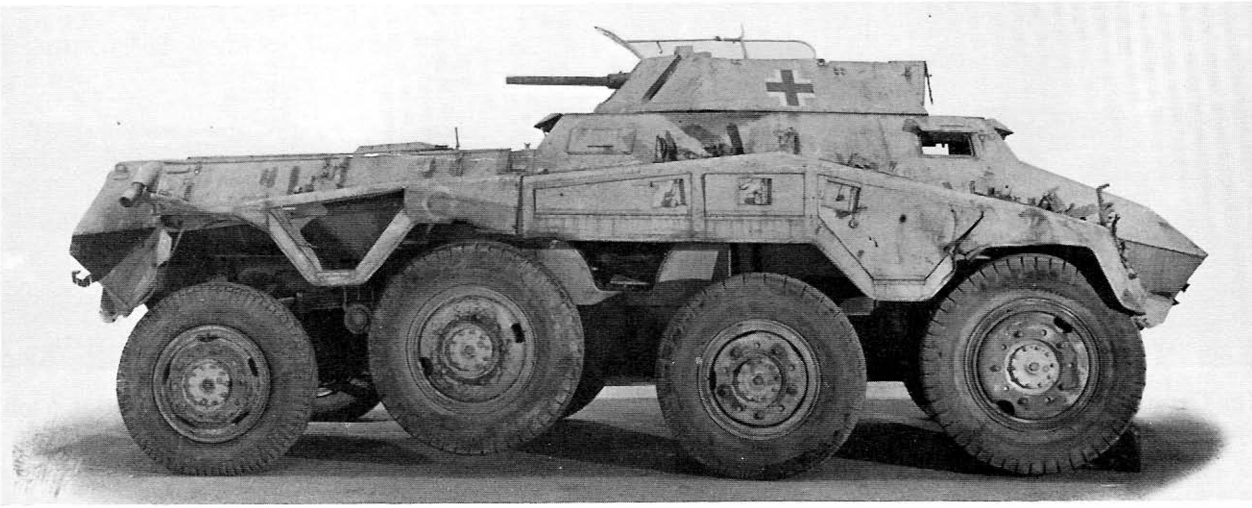
Heavy Armored Scout Car (2 cm) (Sd. Kfz 234/1)



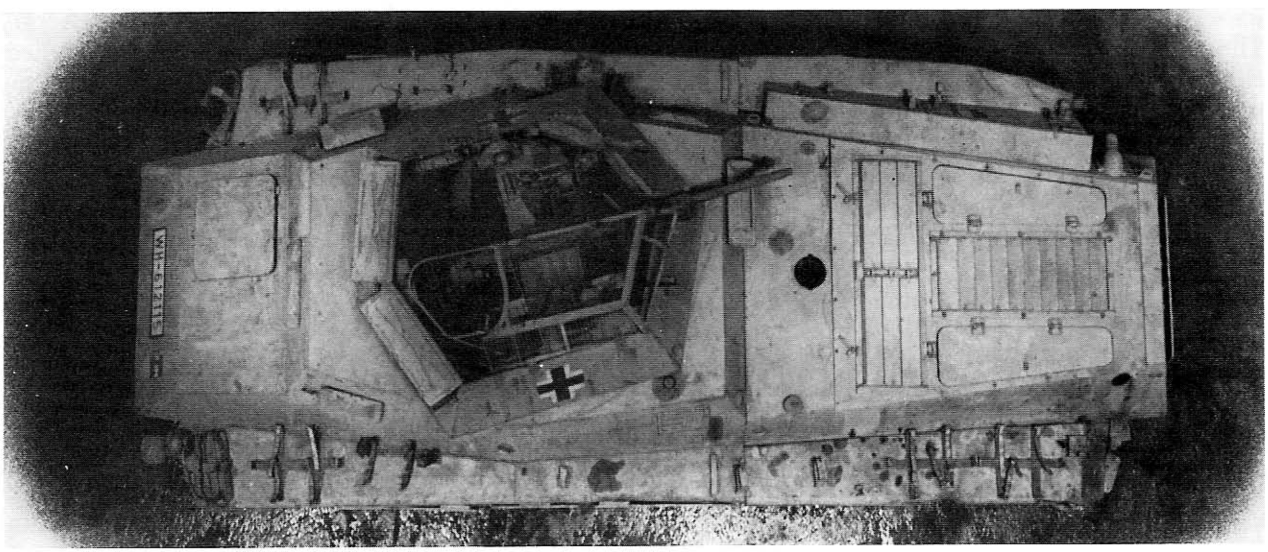
Heavy Armored Scout Car (2 cm) with Swivel Mounting



A rare installation, a 2 cm tank gun with a Flak barrel, swivel mounted on the heavy armored scout car (Sd. Kfz 234).



The basic heavy, armored scout car (Sd. Kfz 234) was also alternatively equipped with the suspension mount 38. This vehicle continued being produced until the war ended. The photographs show both side and plan views of the heavy armored scout car.



4.3 Unarmored Half-Tracks as Anti-Aircraft Gun Carriers

Increasing vehicle combat weights, brought about by larger vehicle crews, weapon mountings and on-board ammunition supplies, led to the conclusion, that half-tracked vehicles, already in service with the Army, should be adapted as Anti-Aircraft Gun Carriers. During the course of such development several half-tracked vehicles, carrying a variety of armaments were designed. Prototypes were built, tested and in some cases commissioned into service. As motorization of the Deutsche Reichswehr and later the Wehrmacht progressed, the Army Ordnance Office, Dept. Wa-Prüf 6. developed, in all a total of six-different types of half-tracked vehicles. All these vehicles were very similar in their basic design. The technical responsibilities for these vehicles rested with Dipl.-Ing. Ernst

The German Wehrmacht's family of half-tracked tractors. (From left to right) the 1 ton tractor, 3 ton tractor, 5 ton tractor, 8 ton tractor, 12 ton tractor and 18 ton heavy tractor.

Kniepkamp. He had been employed by the Army Ordnance Office since 1925, being promoted in 1936, to head of tracked vehicle development, Army Ordnance Office, Dept. Wa. Prüf. 6.

The planned production programme foresaw development of the following weight classes of half-tracked vehicles:

1 ton – Half-Track, Parent Co., Demag AG, Wetter-Ruhr

3 ton – Half-Track, Parent Co., Hansa-Lloyd-Goliath AG, Bremen (nor intended for air defense applications)

5 ton – Half-Track, parent Co., Büssing-NAG, Berlin-Oberschöneweide

8 ton – Half-Track, Parent Co., Krauss-Maffei AG, München

12 ton – Half-Track, Parent Co., Daimler-Benz AG, Berlin-Marienfelde

18 ton – Half-Track, Parent Co., Famo, Breslau

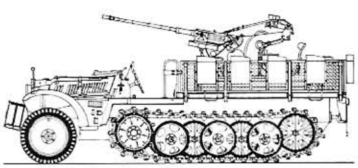
Technical lay-out of all of these vehicles followed the same basic guide lines. All the half-tracks had pneumatic types on their front wheels, the rear suspension consisted of staggered roadwheels with lubricated tracks with rubber pads. These vehicles were powered by either six or twelve cylinder, liquid cooled, high performance petrol engines. Engine power to the running gear was transferred via a disc-clutch to the variable gearbox, integrated within a common housing with the transmission, reduction and "Cletrac" steering gears. Tractive power to the forward track-drive sprockets taking place via traversely driven shafts and spur gears. Whereas the free-running front axles had leaf springs, the tracks running gear initially had a combination of helical and semi-leaf springs. In later models this was modified when torsion bars were extensively used. With the exception of the 1 ton vehicle which used a monocoque form of construction, the remaining vehicles had chassis frames made from two pre-fabricated, welded longitudinal main members, with welded – in U section and tubular crossmembers.

In the following year, five types of these half-tracks underwent further development to serve as half-tracked, self-propelled, anti-aircraft gun carriages, some of which went into limited series production.

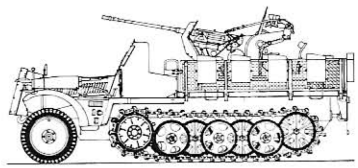
To facilitate being used purely as tractors, guns and their mounts could be easily dismantled from the vehicles with a miniumum of effort, an advantage which was very rarely used.

The tactical application of these vehicles was primarily that of air defense, however during the war they were increasingly deployed in combat against ground targets, a purpose for which they had neither been developed nor planned. Anti-Aircraft batteries equipped with these self-propelled, half-track gun carriages could travel on built-up roads at up to 30 km/h and across-country at 12 km/h. In one days travel they could cover up to 250 km.

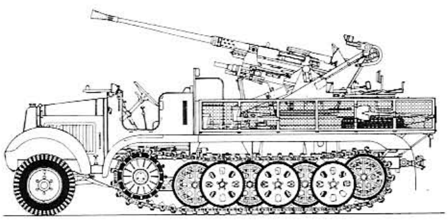
Comparison of half-tracked tractors



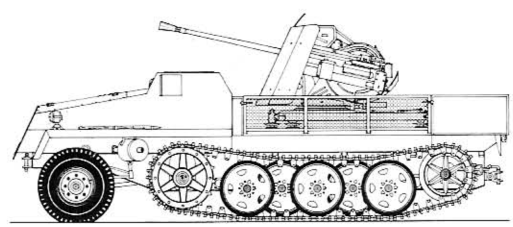
Self-propelled Gun Carrier (Sd. Kfz 10/4) armed with 2 cm Flak 30 cannon



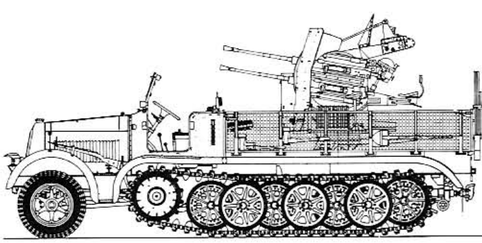
Self-propelled Gun Carrier (Sd. Kfz 10/4) armed with 2 cm Flak 30 cannon – partially armored



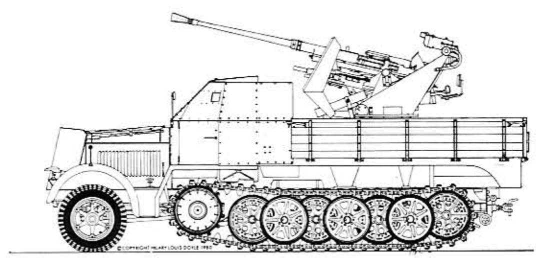
Self-propelled Gun Carrier (Sd. Kfz 6/2) armed with 3.7 cm Flak 36 cannon



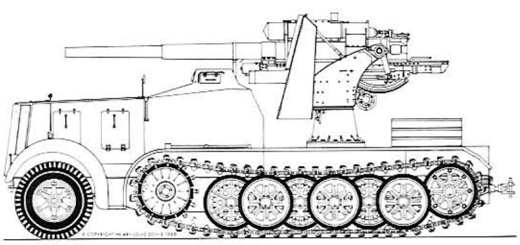
Heavy Wehrmacht Tractor armed with 3.7 cm Flak cannon



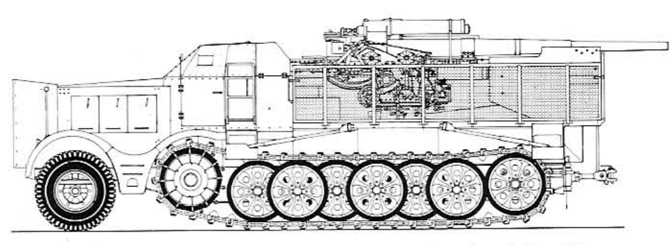
Self-propelled Gun Carrier (Sd. Kfz 7/1) armed with quadruple, 2 cm Flak 38 cannon



Self-propelled Gun Carrier (Sd. Kfz 7/2) armed with 3.7 cm Flak 36 cannon



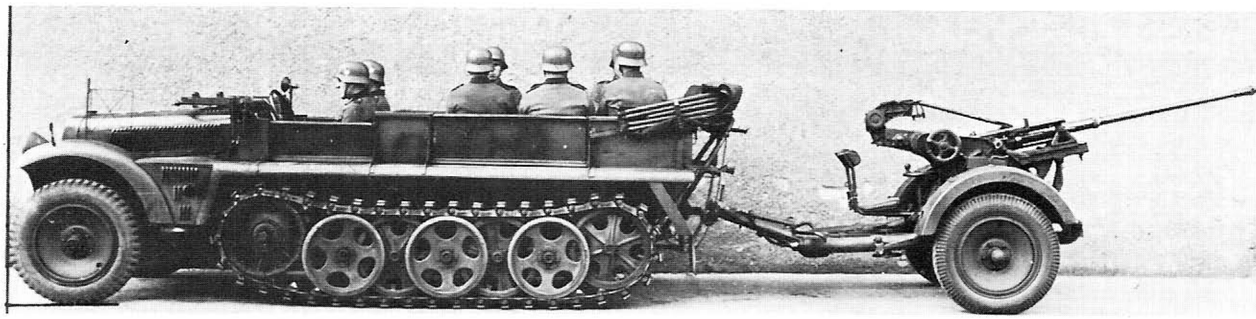
8.8 cm Flak 18 cannon mounted on the chassis of the 12 ton Tractor



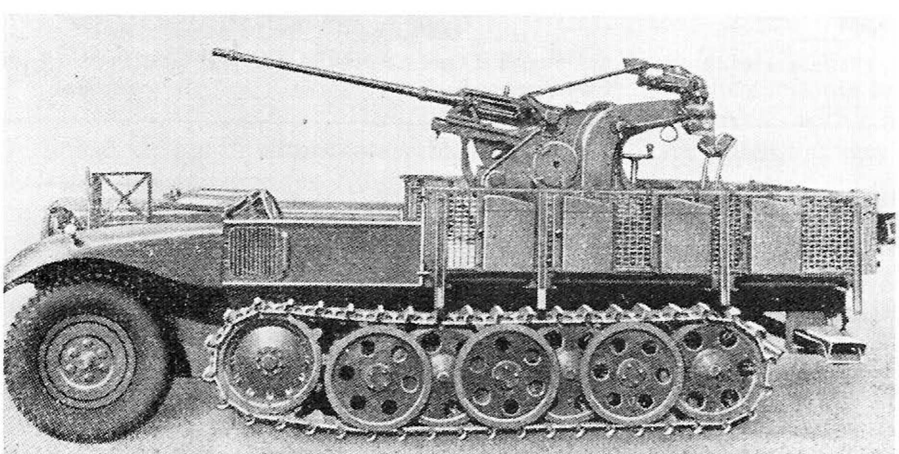
8.8 cm Flak 37 cannon mounted on the chassis of the 18 ton Tractor

4.3.1 1 t Half-Track Tractor

In the years 1934/35 the company Demag AG, at their Wetter Works/Ruhr, developed the first prototypes of this one-ton vehicle, these were type designated as D ll 1 and D ll 2 respectively. In 1936, the third prototype the D ll 3 had a BMW, type 319, six-cylinder petrol engine installed. Some of these prototypes were built later as self-propelled carriers for the 2 cm-Flak 30 cannon. The weapon was mounted in the crew compartment and no armor protection was provided. Type D 7 was the last designated configuration of these 1 t half-tracked tractors to be produced. In all between the years 1938 to 1944 an approximate total of 17,500 units were manufactured.

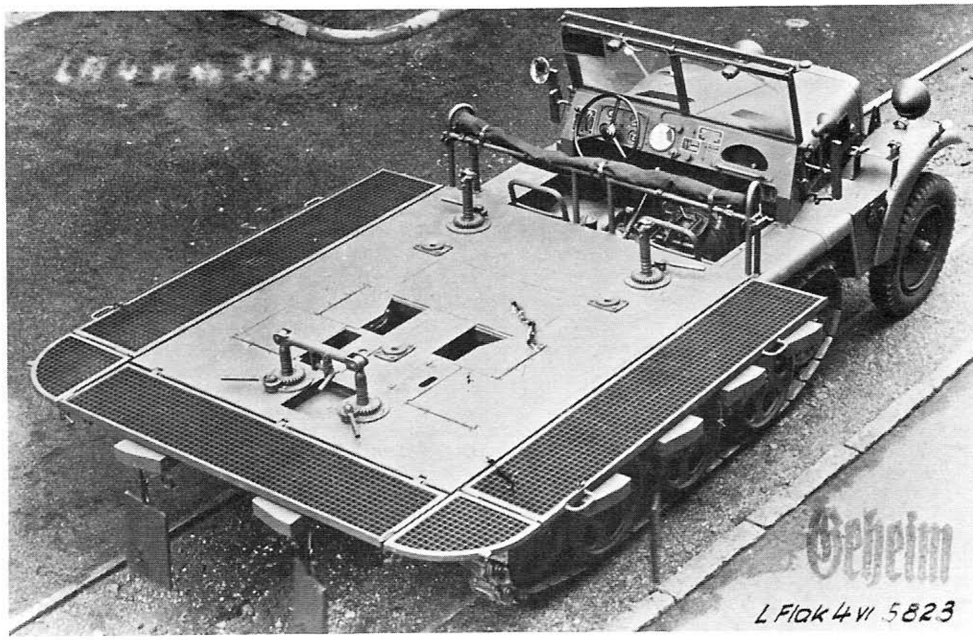


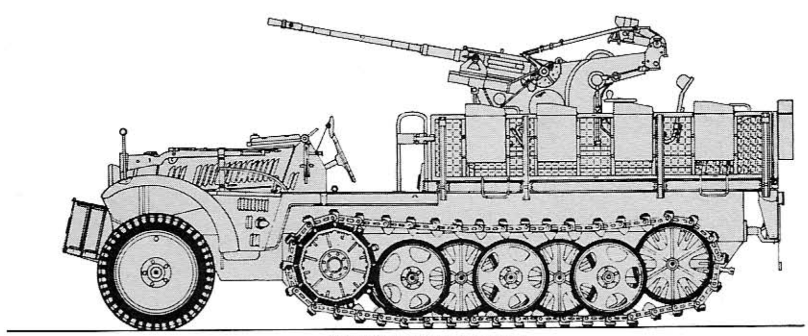
The light, 1 ton Tractor (Sd. Kfz 10) served as the standard vehicle for towing the 2 cm Flak 30 cannon. the lower photograph shows the crew seated, the upper, the 2 cm Flak 30 aboard its special trailer type 104, coupled for towing.



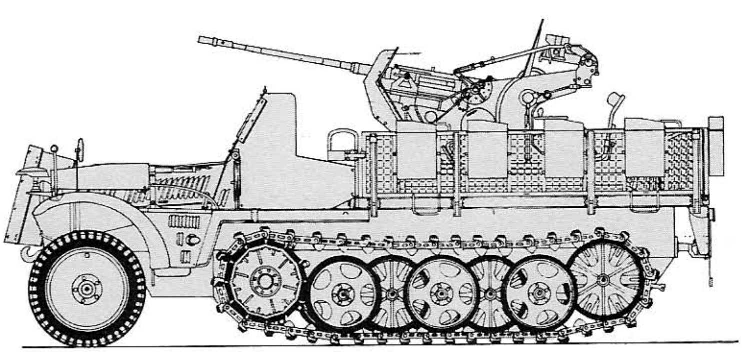
Even during development, the 1 ton half-track tractor was intended as a self-propelled carrier vehicle for the 2 cm Flak 30 weapon. The photograph shows a prototype, unarmored version of the type D ll3 vehicle.

The final production model of the 1 ton series vehicle, designated type D 7, was intended as the standard self-propelled gun carrier. Photograph show the platform ready for installing the 2 cm Flak 30 weapon with the side and rear boards lowered to serve as gun platform.

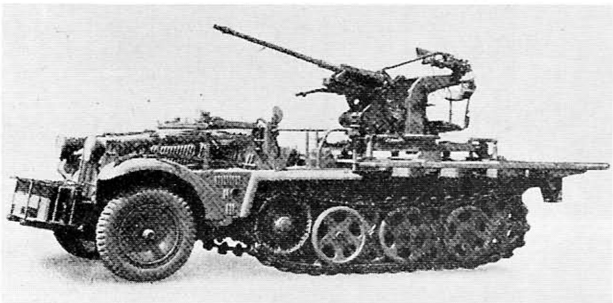




Self-propelled gun carrier (Sd. Kfz 10/4) armed with the 2 cm Flak 30 cannon



Partially armored version of the self-propelled (Sd. Kfz 10/4) carrier armed with the 2 cm Flak 30 weapon



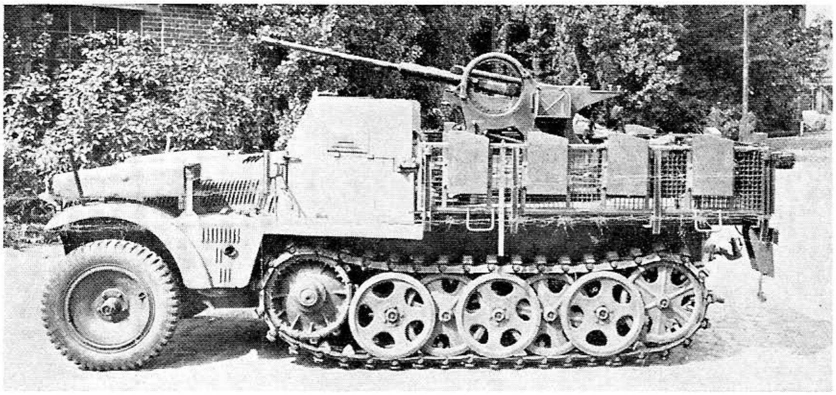
A self-propelled gun carrier armed with the 2 cm Flak 30 (Sd. Kfz 10/4). Photographs show the crew in mounted and dismounted positions.

In action, the 2 cm Flak gun carrier was completely unprotected, particularly so when engaging ground targets.

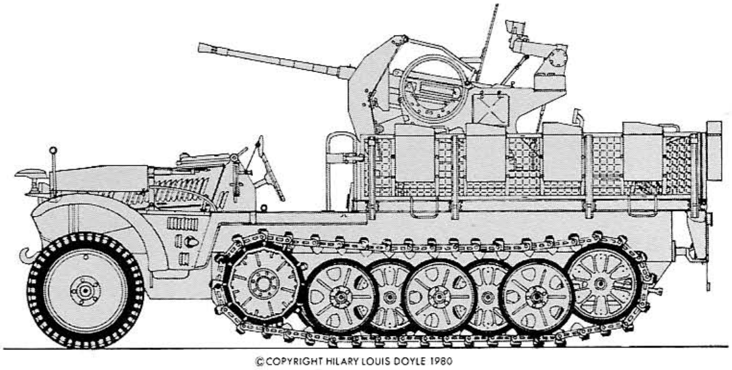
These tractors were also series-produced as self-propelled gun carriages, mounting as armament the 2 cm Flak 30 cannon, which was fully traversable through 360°. A seven-man crew was carried together with some of the guns equipment and two hundred and eighty rounds of ammunition. Other auxiliary equipment being towed behind on a single axle trailer. Maximum road speed was 50 km/h. These vehicles were designated as "self-propelled, gun carriers (Sd. Kfz. 10/4) with 2 cm Flak 30 cannon".

Prior to commencing the French campaign in 1940, some of these vehicles received auxiliary ar-

mor which had been manufactured by the Röchling-Works. After the initial experiences of the French campaign, both the 2 cm Flak 30 and 38 were very quickly fitted with armored gun shields. Only in rare cases were the drivers cabs fitted with any armored protection. This weapon system was wideley distributed amongst all the light Flak-batteries of both army and Luftwaffe, proving its excellent capabilities in both aerial and ground combat.



It was only during the course of World War II that the self-propelled gun carriers were first fitted with gunshields (upper photo) and driver cab protection (lower photo).



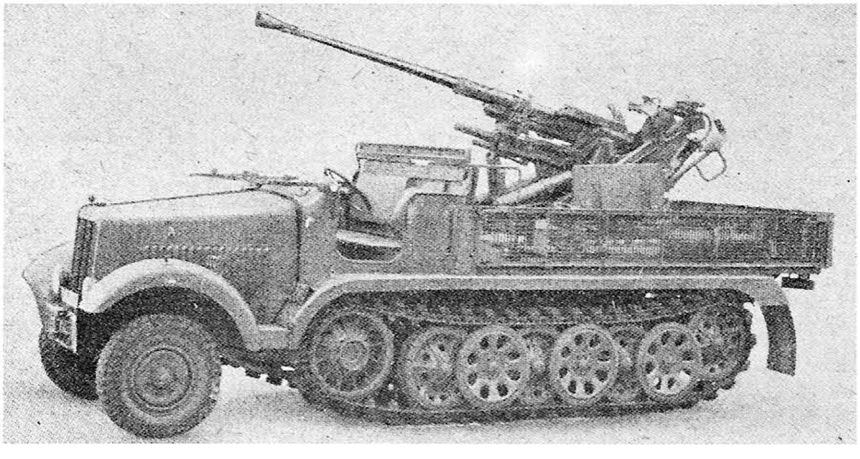
A self-propelled (Sd. Kfz 10/4) carrier armed with a 2 cm Flak 38 cannon

4.3.2 5 ton Half-Track Tractor

The initial development of this vehicle was started by Krauss-Maffei, Munich Allach, the first prototype vehicle, the KM 1 4 being built as early as 1934. This development took place under a contract with the Army Ordnance Office, Dept. Wa. Prüf. 6. Series production of this 5 t half-track was however transferred to the Büssing-NAG Co., Berlin-Oberschöneweide early in 1935. Whereafter an improved BN 1 5 model entered series production at the end of the same year. This was followed in 1936 by the BN 1 7 model, superseded in 1938 by the BN 1 8. Final configuration of this series of half-tracks was the BN 9 model, which began series production in 1939. By the year 1943, approximately three thousand five hundred of these vehicles had been built and were in service with the troops.

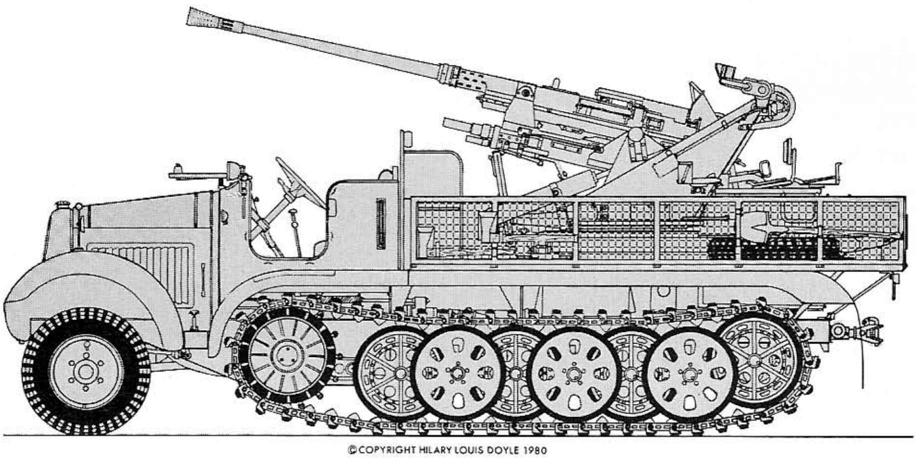
Both Luftwaffe and Army air defense units were equipped with half-track, self propelled 3.7 cm Flak (Sd. Kfz 6/2) gun carriages based on the above vehicle. These vehicles had, inclusive of their seven-man crew, a combat weight of 10.4 tons. The major ammunition supply was towed behind the vehicle on a single axled special trailer.

Photograph illustrates the gun-crew stations on a Sd. Kfz 6/2 vehicle. When ready for action the side boards were lowered. At the left a crew member using the range finder.



The standard carrier vehicles for the 3.7 cm Flak 36 cannon (Sd. Kfz 6/2) used the chassis of the 5 ton half-track. These vehicles also remained in general free of armor protection.

The self-propelled gun carrier (Sd. Kfz 6/2) mounting a 3.7 cm Flak 36 cannon

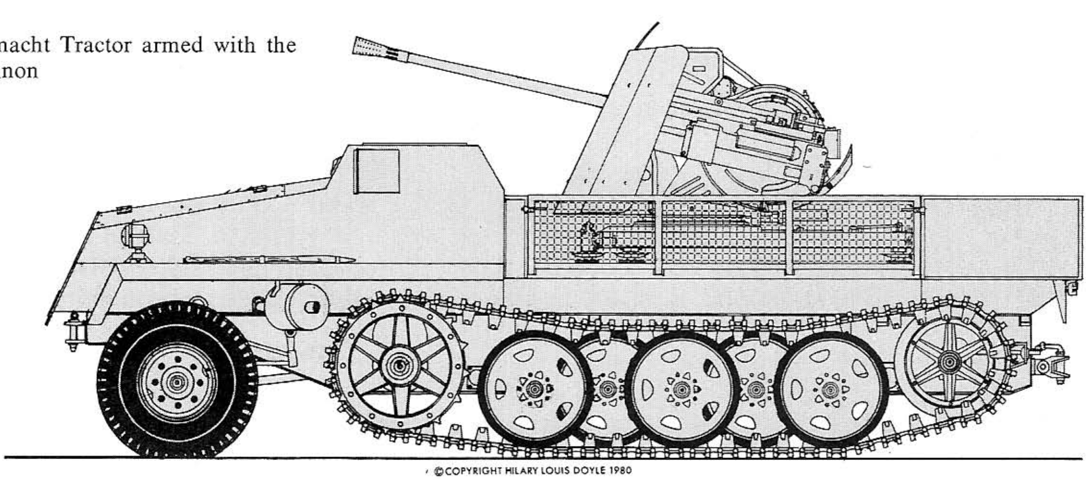


4.3.3 Heavy Wehrmacht Tractor

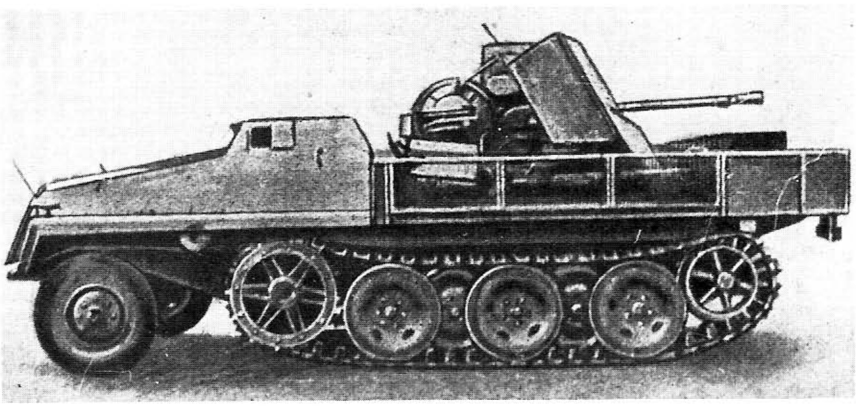
Endeavours by the Army Ordnance Office, to simplify equipment constructions, planned replacement of the 5 t half-track tractor, from 1943 onwards by a new utility vehicle. On May 7th, 1942 the Büssing-NAG Co. received a development contract from Dept. Wa Prüf. 6 of the Army Ordnance Office for a new prime mover with a six-ton towing capacity as well as a three ton payload. The newly developed vehicle as it materialized had been severely simplified, running on dry (unlubricated) tracks. It was powered by a Maybach (HL 42) six-cylinder, petrol engine producing 100 HP. This so-called "Heavy Wehrmacht Tractor" weighed 13.5 tons had a maximum road

The heavy Wehrmacht Tractor, with the gun-loaders feeding the racked 3.7 cm ammunition.

The heavy Wehrmacht Tractor armed with the 3.7 cm Flak 43 cannon



speed of 29 km/h. After the trials phase had been concluded, this vehicle was series-produced by both Büssing-NAG in Berlin-Oberschöneweide and Ringhoffer-Tatra in Kolin (Bohemia). A partially armored version was built and employed as a self-propelled gun carrier for the 3.7 cm Flak weapon, many of which were in service until the war ended.

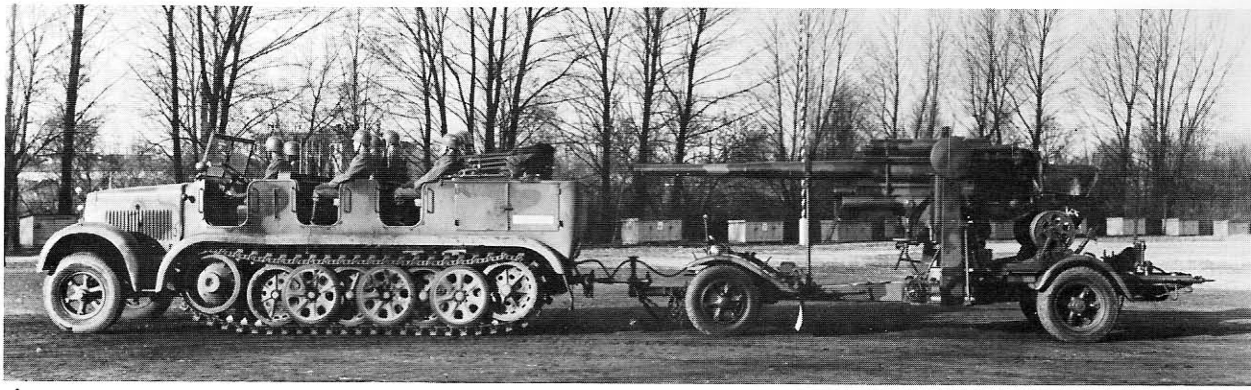


A heavy Wehrmacht Tractor as self-propelled anti-aircraft gun, armed with the 3.7 cm Flak cannon. The photos show the vehicle in both "march" and "engagement" positions.

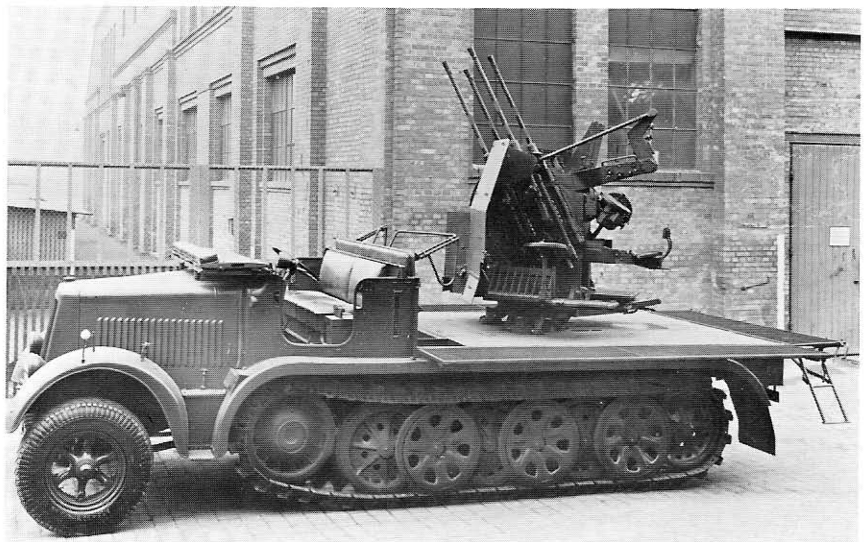
4.3.4 8 ton Half-Track Tractor

Krauss Maffei AG were the acknowledged pioneers of German half-track vehicle development. As early as April 1933, they had, in close co-operation with Dept. Wa Prüf 6 of the Army Ordnance Office, presented the first KMZ 85 prototype vehicle. Without resorting to design features of commercial trucks, Krauss-Maffei created a vehicle which was in all configurations by far superior to all known prime movers. In 1933/34 KMZ 85 and KMZ 100 were developed into the O-series KM 7 and KM m 8 production vehicles, the latter in 1934. The last configuration of these vehicles produced, the KM m 11 was a final derivative of the KM 9 and KM 10 vehicles, generally deployed for towing the 8.8 cm, Flak 36 Anti-Aircraft guns. In all, five thousand and twenty-six of these vehicles left Krauss Maffei's production lines in Munich-Allach.

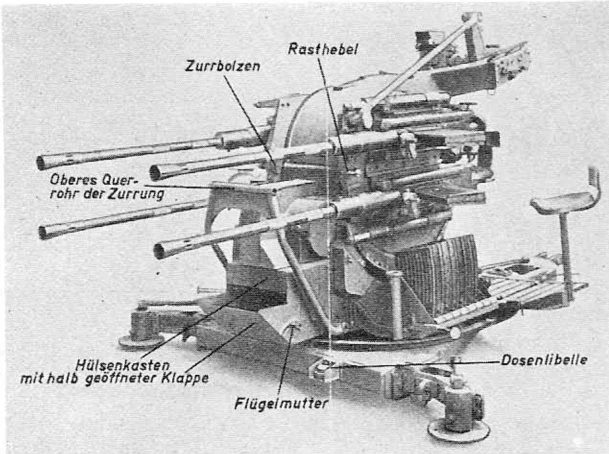
The KM m 11 was also built to serve as a self-propelled gun carriage suitable for mounting a variety of anti-aircraft guns.

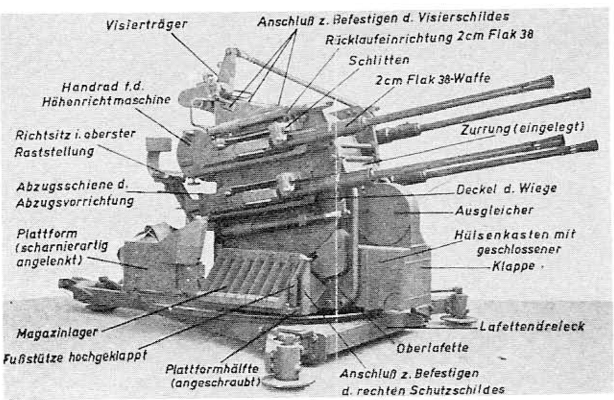


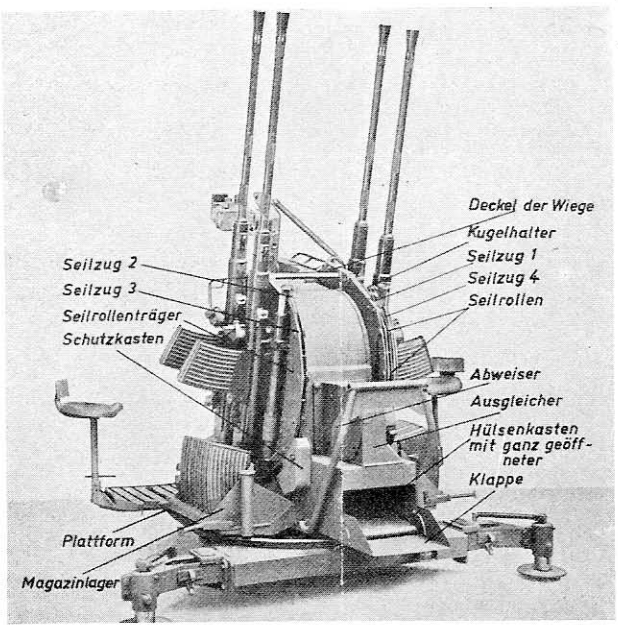
▲
A medium 8 ton Tractor (Sd. Kfz 7) serving as prime mover for a 8.8 cm Flak 36 weapon.

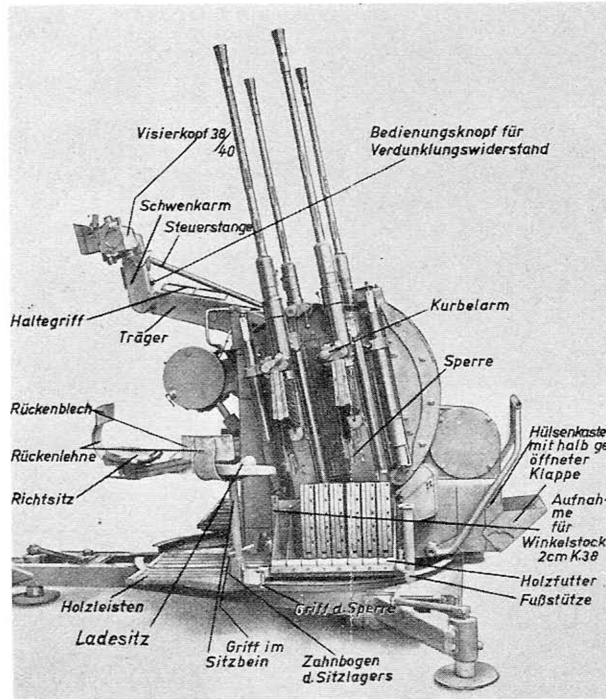


Two works photographs taken at the premises of the Lindner Co. Ammendorf, show acceptance of a self-propelled carrier for the quadruple, 2 cm Flak 38 (Sd. Kfz 7/1). This was the original version and shows the weapons with and without gun-shield.









▲ A 2 cm quadruple Flak 38, viewed from the right with barrels elevated through approx. 100°.

Top Left. 2 cm quadruple Flak, viewed from the front left, with barrels at 0°.

◀ 2 cm, quadruple Flak 38, viewed from the front right.

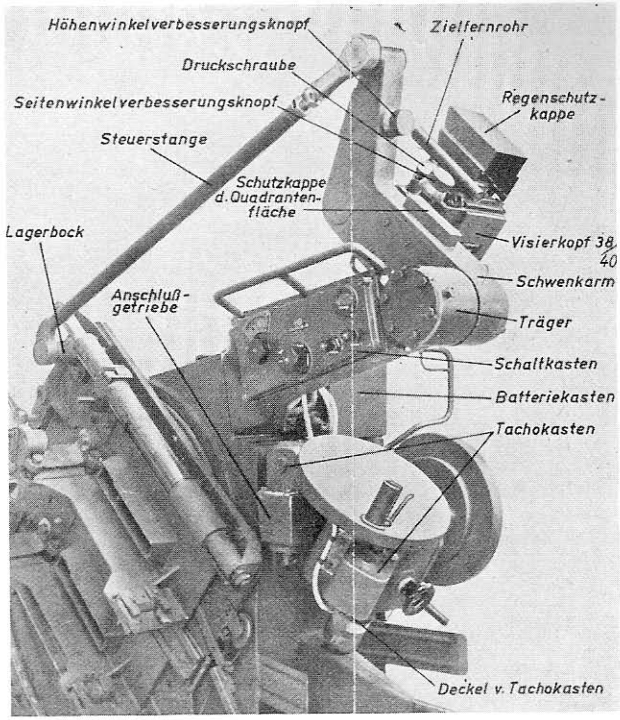
◀ The 2 cm Flak 38 again viewed from the front right, with weapons elevated to approximately 75°.

One special version, the Sd. Kfz 7/1 was a carrier armed with 2 cm quadruple, Flak 38 cannon. Its combat weight of 11.54 tons resulted from the weight of the vehicle, armament, ancillary ordnance equipment, gun commander, four-man gun crew and six hundred rounds of ready ammunition. Further miscellaneous equipment and supplementary ammunition being towed behind on a single-axled trailer (special trailer 56).

After the outbreak of war, these weapons were fitted with protective armor shields, in some individual cases both the drivers cab and engine received sheet armor protection. Some troops at their own initiative, mounted a 2 cm Flak 30 weapon

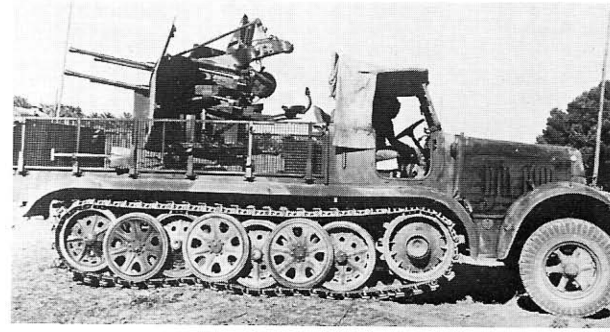
on these vehicles. Another special version, the Sd. Kfz 7/2 was armed with the 3.7 cm Flak 36, had a seven-man crew and a combat weight of 11.05 tons.

For trial purposes in 1943, Rheinmetall-Borsig installed a 5 cm, Flak 41 on the chassis of the eight ton half-track tractor. The very powerful recoil occurring when this weapon was firing being absorbed by four, laterally mounted outrigger supports. These supports and readying them drastically influenced the time taken preparing the gun into a ready-to-fire position.



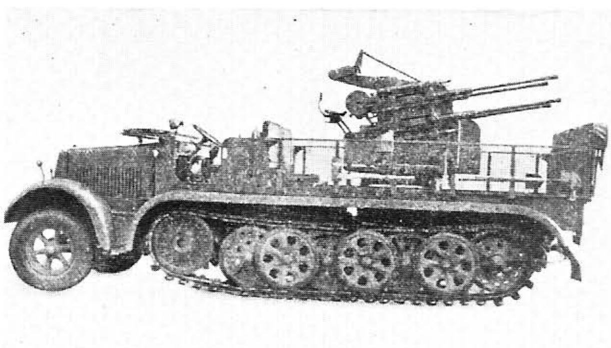
2 cm, quadruple Flak 38, Sighting Mount fitted with the Flak 40 sight.

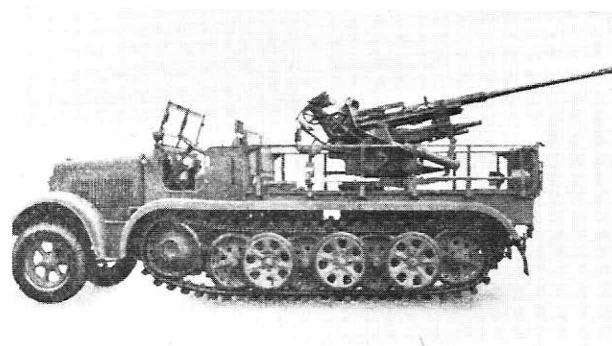
Typical deployment of the Flak self-propelled gun carriers during the latter years of the war. A purpose for which they had never been intended. When counter attacking, these almost completely unprotected vehicles provided supporting fire while advancing in reverse gear (Sd. Kfz 7/1).



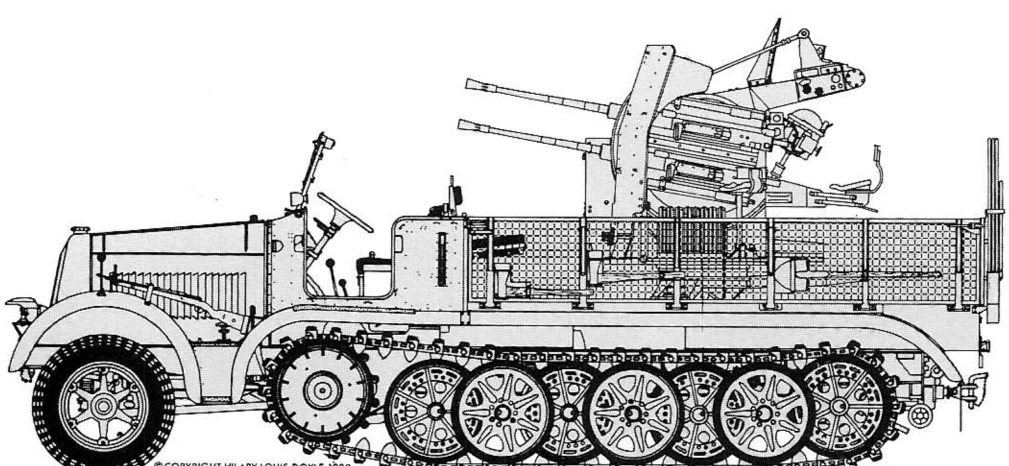
The quadruple, 2 cm Flak 38 cannon on an 8 ton tractor, with the weapons in the "march" position.

The vehicle in action. The weapons having received an armored gun-shield.



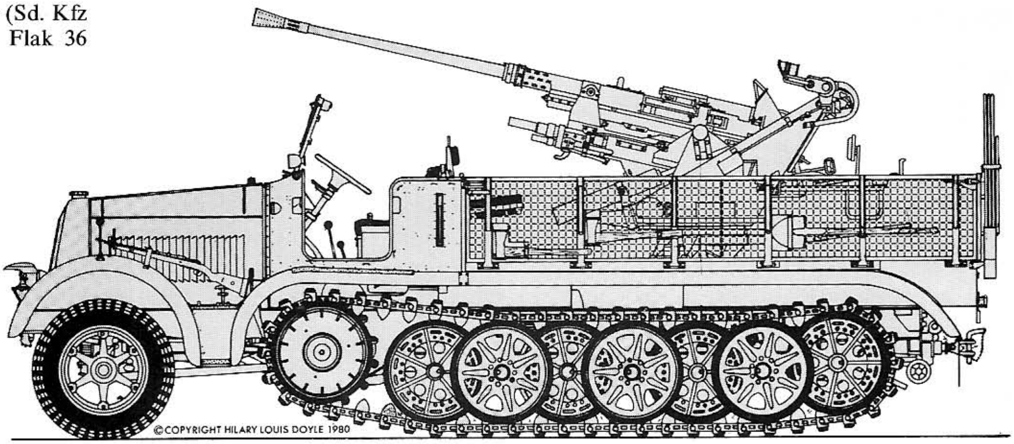


A comparison between two self-propelled Flak vehicles, on the left. a Sd. Kfz 7/1 armed with the quadruple 2 cm, Flak 38, on the right a Sd. Kfz 7/2 with 3.7 cm Flak 36.

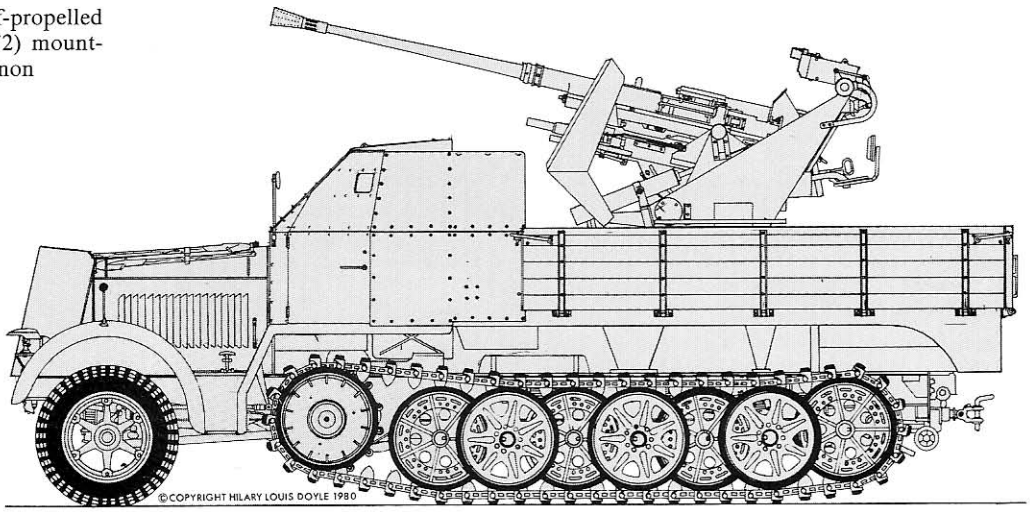


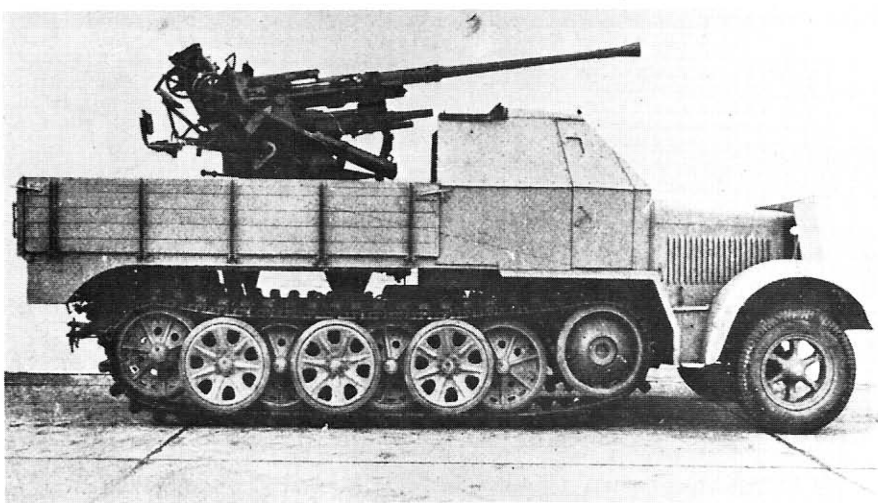
Self-propelled carrier (Sd. Kfz 7/1) armed with the quadruple, 2 cm Flak 38 weapon

Self-propelled gun carrier (Sd. Kfz 7/2) mounting a 3.7 cm Flak 36 cannon

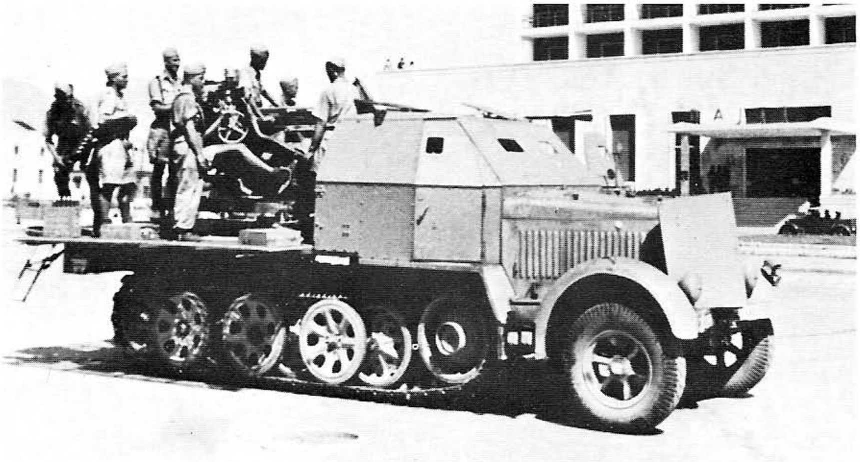


Partially armored, self-propelled gun carrier (Sd. Kfz 7/2) mounting a 3.7 cm Flak 36 cannon

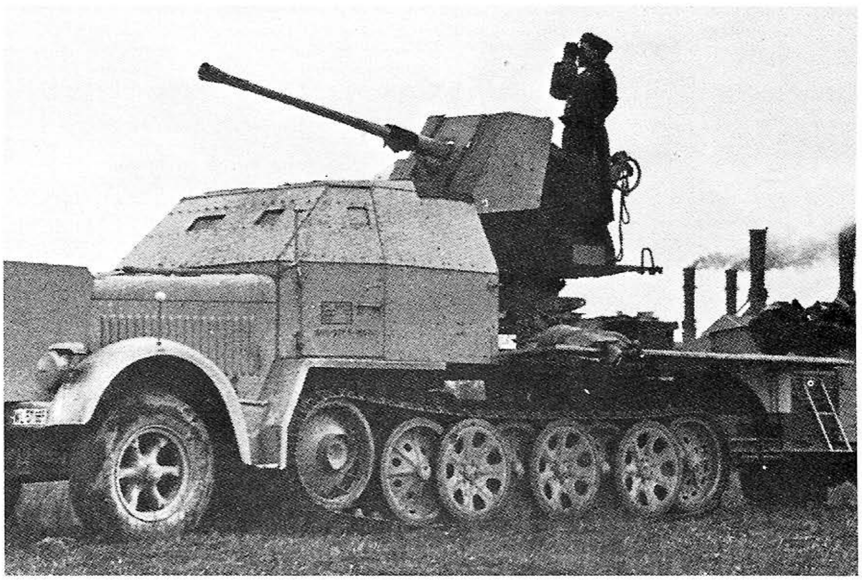


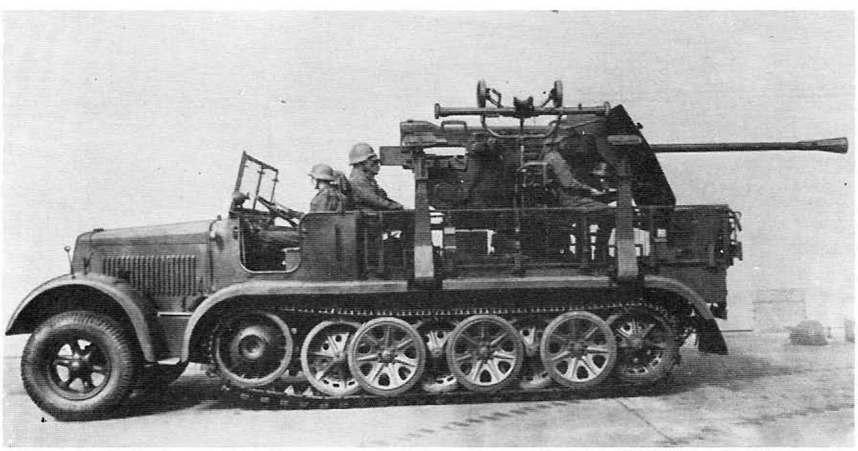


Self-propelled, 3.7 cm Flak, gun carrier mounted on 8 ton (Sd. Kfz 7/2) half track tractor. Fitted with armored drivers cab and radiator shield (final version).



A self-propelled 3.7 cm Flak vehicle in action, during World War II.

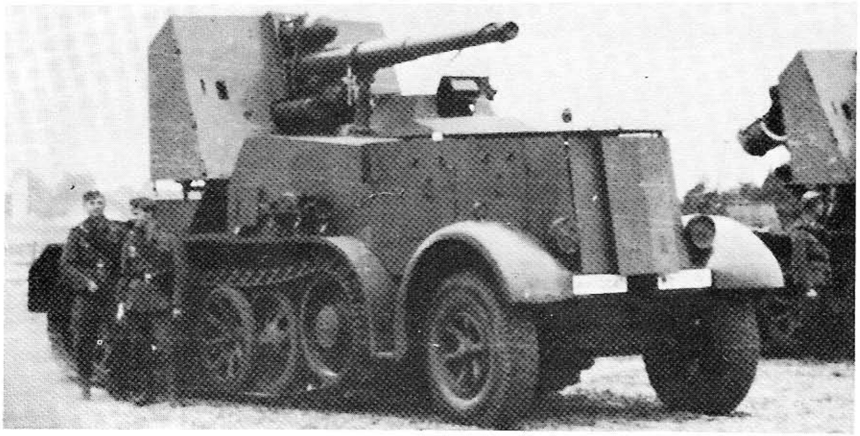




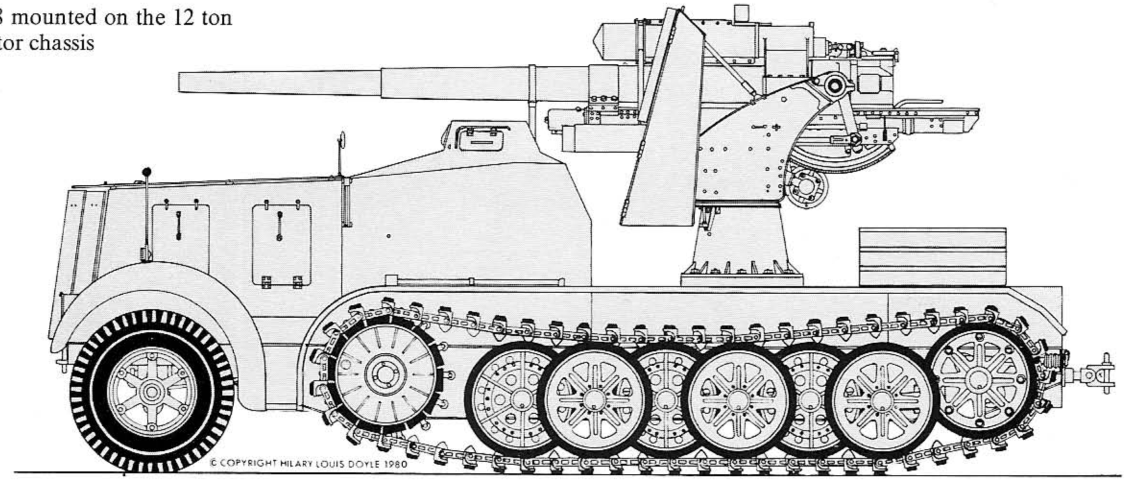
For trials purposes, a 5 cm Flak 41 weapon was mounted on an 8 ton half-track tractor. Prior to commencing firing the suspension had to be eliminated. This was done by fitting outrigger supports laterally.

4.3.5 12 ton Half-Track Tractor

The 12 ton heavy tractor was developed by Daimler-Benz in accordance to design parameter which had been established by Dept. Wa Prüf 6 of the Army Ordnance Office. During the war this vehicle was also manufactured by both Krupp and Krauss-Maffei. It was in 1934 that the first production model, the DB s 7 made its initial debut, being superseded in 1936 by the DB s 8 model. In the years 1938–1939 a further version, the DB s 9 was built. The final version produced, designated DB 10 continued being produced until 1945.
From October of 1939, based upon the 12 ton DB s 9 tractor, a total of twelve self-propelled gun carriers armed with 8.8 cm, Flak 18 guns were built and delivered to the troops. These seeing their first action during the French campaign in 1940. By mounting such heavy air defense ordnance on these vehicles, the first steps had been taken in establishing a dual capability weapon system, deployable against both aircraft and armor.



Only twelve of these self-propelled carriers were built based on the 12 ton tractor vehicle. Mounting the 8.8 cm Flak 18 weapon, they were primarily intended for an anti-tank role.



8.8 cm Flak 18 mounted on the 12 ton half-track tractor chassis

4.3.6 18 ton Half-Tracked Tractor

The heaviest of the German Half-track Tractor developments first appeared in 1936 when the FM gr 1 model was introduced. After an intermediate F 2 version, the finalised, eighteen ton, F 3 model came into being. This model was manufactured by the Famo Co. of Breslau until shortly before the war ended. In general this vehicle primarily served for tank recovery operations.

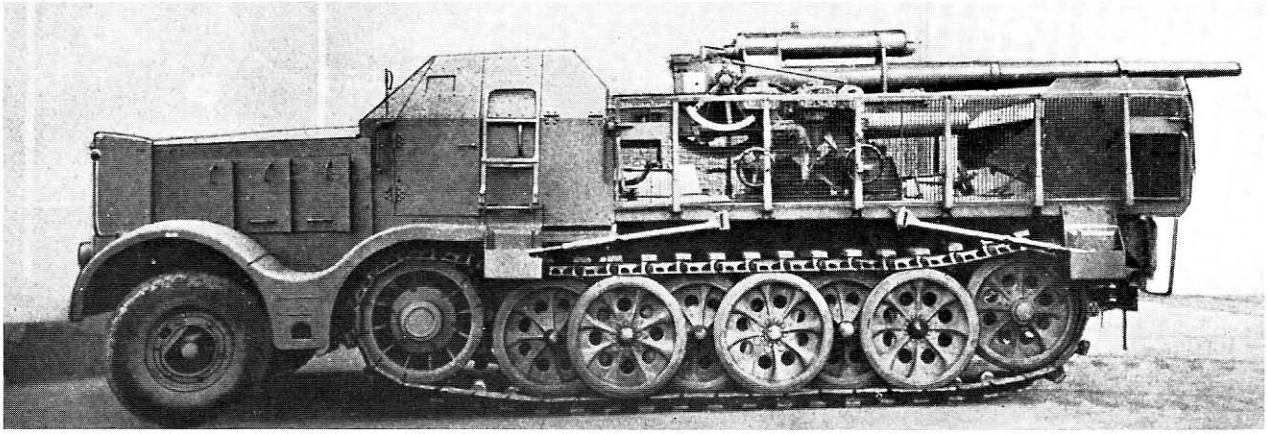
Some small number of vehicles were also converted into self-propelled, heavy anti-aircraft gun carriers.

A requirement from the Reich Air Ministry in 1942 requested procurement of a total of one hundred and twelve self-propelled gun carriers based upon this vehicle, all mounting 8.8 cm Flak 37 weapons. In June and July 1943 the Weserhütte Co. of Bad Oeynhausen built a total of fourteen of these vehicles. Due to the increased combat weight of twenty-five tons the suspension torsion bars had to be strenghened. Both the engine and drivers cab were protected by 14.5 mm thick armor, a total of forty ready rounds of ammunition was carried on-board. This vehicle as such, was rejected as unsuitable on January 18th 1943, firstly as a heavy anti-aircraft gun carrier by the air force and as an anti-tank vehicle by the army. They were to be replaced by an experimental Flak vehicle (VFW) which had been conceived by Krupp.

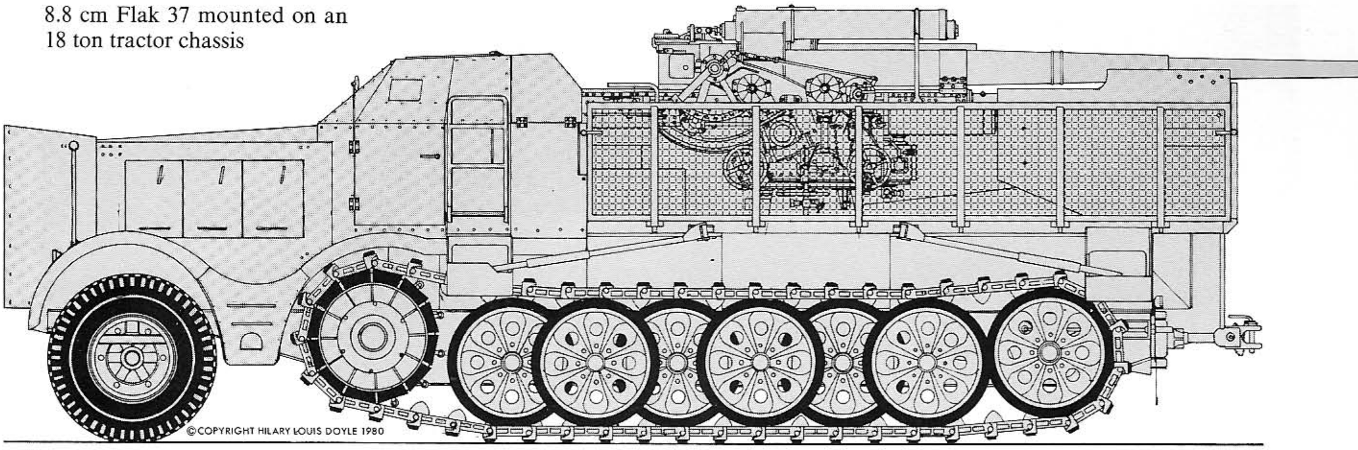
Rheinmetall-Borsing drawings dated 1939, illustrate two of their design proposals for mounting twin, 7.5 cm anti-aircraft guns on the eighteen ton half-track tractor. Their proposed firing height was 2,350 mm with the distance between the parallel sited gun-barrels being 320 mm. It was planned to steady the vehicle when firing by using outrigger supports at both sides and rear. No armored protection was foressen.

As previously experienced with the wheeled, self-propelled gun-mounts, these half-tracks also showed that they had their payload limitations and that their armored protection was inadequate. In spite of their satisfying cross-country capabilities, the height of the weapons mounted upon them, made their deployment a calculated risk.

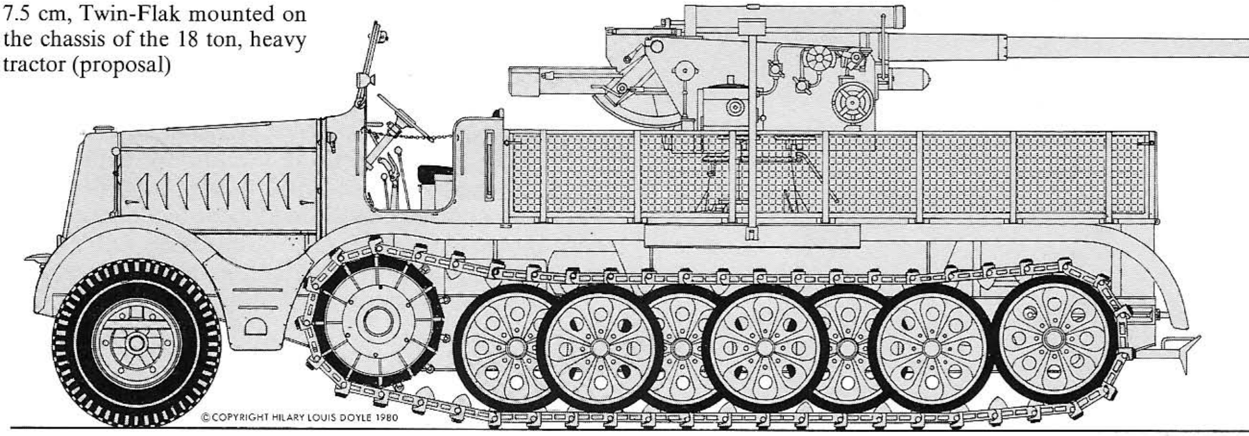
It was originally intended to deploy large numbers of 8.8 cm Flak 37 weapons mounted the 18 ton half-track tractors. However after only fourteen vehicles had been manufactured production was discontinued.



8.8 cm Flak 37 mounted on an 18 ton tractor chassis

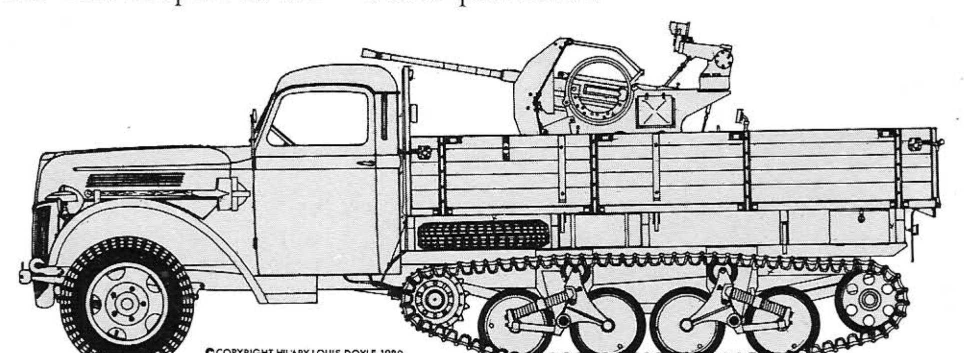


7.5 cm, Twin-Flak mounted on the chassis of the 18 ton, heavy tractor (proposal)



4.3.7 Maultier (Mule) Half-Tracks

In service with the combat troops from 1944 onwards, in addition to the other half-track tractor vehicles were the so-called "Maultier" (Mule) half-tracks. These vehicles were adopted as self-propelled gun-carriages for both the 2 and 3.7 cm Flak cannon. Drawing upon their earlier good experiences with the 2 cm Flak self-propelled carrieres these "mules" were adapted for carrying both the 2 cm and 3.7 cm weapons as a limited field improvisation.



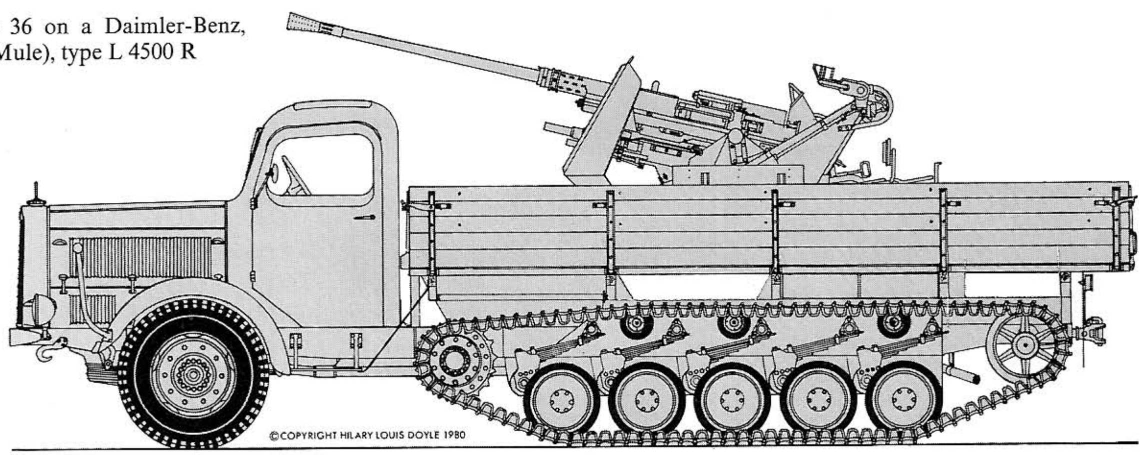
2 cm Flak 38 cannon mounted on a Ford, Type V 3000, S/SSM, "Mule" Truck

Both the light and heavy "Mule" half-tracks were used as auxiliary, self-propelled Flak carriers. The photograph shows a 2 ton Ford Mule mounting a 2 cm Flak 38.

Table 2: Data 2 cm Flak 38 and 3.7 cm Flak 43

Ground Target Range (meters)	*2 cm-Flak 38*	*3.7 cm Flak 43*
Maximum Firing Range	4,400	6,500
Maximum Firing Altitude	3,700	4,800
Most Effective Range	to 2,000	to 3,000
Against susceptible Armored sections	to 600	to 1,400
Against Light Armor	to 300	to 1,000
Weights (in kg.)		
Mounted on 1 t Half-Track	4242	–
Mounted on "Mule" Carrier	6616	–
Mounted on 8 t Half-Track	–	10,500
On-board Ammunition (no of rounds)		
Incendiary, high-explosive with tracer	480	1,290
Incendiary, high-explosive	480	–
Armor piercing with tracer and detonator	480	320

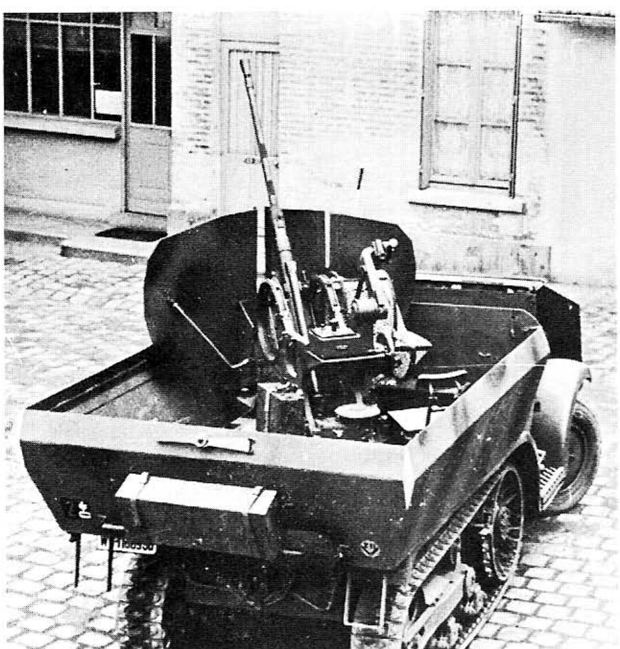
3.7 cm Flak 36 on a Daimler-Benz, "Maultier" (Mule), type L 4500 R

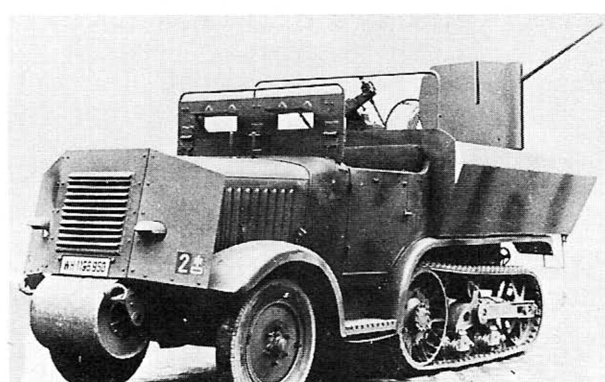


4.3.8 French Half-Tracks

In 1943, instigated by a Lt. Col. Alfred Becker (Commander of the 200th Assault Gun Battalion, 21st Armored Division), the Paris Agency of the German Army Ordnance Office, decided to convert captured French vehicles for alternative purposes. Orders were placed with co-operating French industry to convert some of these vehicles for use as self-propelled anti-aircraft gun carriers. One typical example being the 2 cm Flak self-propelled gun carrier based on the chassis of the P 107 Citroën half-track, large quantities of this vehicle being readily available from captured stocks. These vehicles were systematically dismantled and re-built in lots.

French half-tracks, captured during the French Campaign in large numbers were converted in quantity by the German Wehrmacht and re-deployed. The photographs show a type P 107 Citroën, half-track, 72 of which were fitted with 2 cm Flak 38 cannon. A further 18 with the quadruple, 2 cm Flak 38 weapons. The fighting compartments, driving cabs and radiators of these vehicles all received light armored protection.





For their new roles they received light armor around the radiator, drivers cab and weapon station, protection against infantry small-arms fire. Due to their half-tracked running gears these vehicles possessed good cross-country capabilities. Maximum road speed was 65 km/h. These were good allround vehicle deployable against both air and ground targets.
In all a total of seventy-two of these vehicles were modified and armed with 2 cm-Flak 38 cannon, a further eighteen being equipped with the quadruple 2-cm Flak 38 weapons.

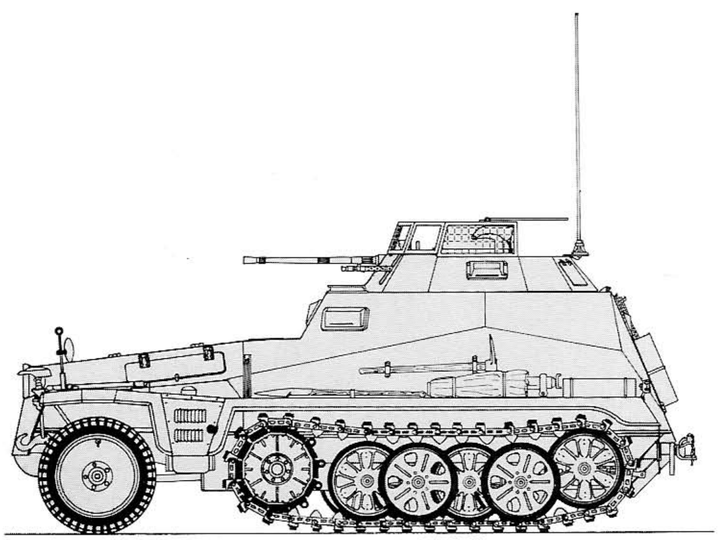
4.4 Half-Track, Armored Personnel Carriers as Self-Propelled Anti-Aircraft Gun Carriages

4.4.1 Light Armored Half-Track (Sd. Kfz 250/9)

Since 1941 the German, wheeled armored reconnaissance vehicles failed almost completely in the bad weather conditions experienced in Russia. Due to the scarcity of fully tracked vehicles, no suitable alternatives were available. This led to Col. General Heinz Guderian making most emphatic demands for the rapid development and large scale production of a suitable reconnaissance vehicle. Proposed was the use of the light armored half-track vehicle using the turret armed with both the 2 cm combat vehicle (KwK 38) cannon and type 42 machine gun of the wheeled light armored reconnaissance vehicle (Sd. Kfz 222)

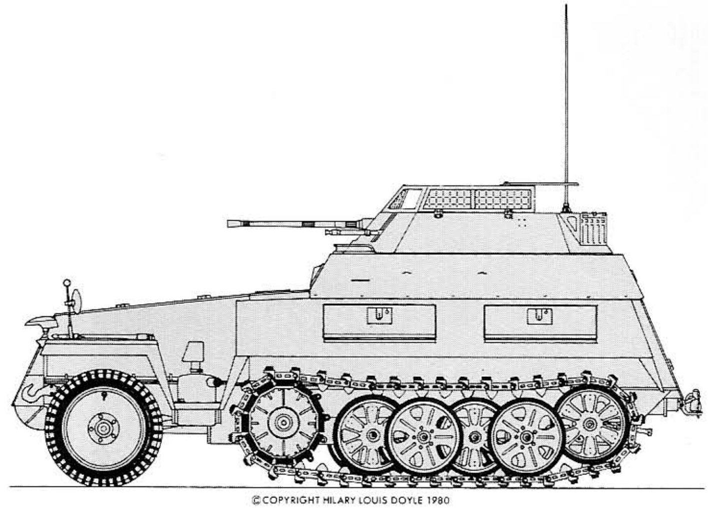
In compliance with these demands Dept. Wa Prüf 6, of the Army Ordnance Office, commissioned the Gustav Appel Co., of Berlin-Spandau to develop such a light, armored, reconnaissance half-track (Sd. Kfz 250), including a turret mounting the 2 cm socket mount 38 of the light, armored (Sd. Kfz 222) vehicles. By July of 1942, three trials vehicles were undergoing intensive field tests on the Eastern Front.

An initial production batch of thirty vehicles were built, however in accordance with a modification contract issued by Dept. Wa Prüf 6, Army Ordnance Office, the Appel Co. replaced the 2 cm-Socket Mounts with 2 cm-38 suspended gun cradlemount. These vehicles carried in all one hundred rounds of 2 cm ammunition on-board. Including three-man crew the combat weight of the light armored halftrack (2 cm) (Sd. Kfz 250/9) was 5.9 tons. Vehicles of this type remained in service until the end of the war.



Light armored infantry vehicle (Sd. Kfz 250/9)

Light armored infantry vehicle (Sd. Kfz 250/9) final configuration



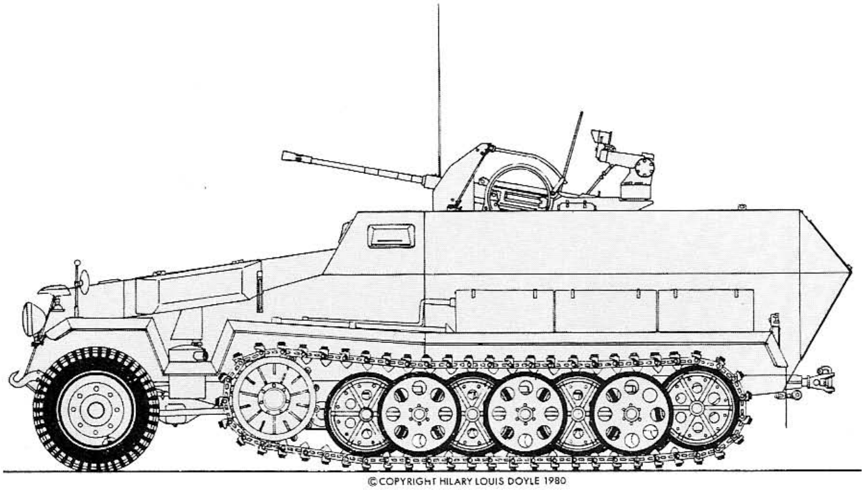
Armored reconnaissance vehicles based upon the light (Sd. Kfz 250/9) armored infantry vehicle. The photographs show both front and rear views of the vehicle. The turret mounted is that of the light wheeled scout car, also suited for air defense purposes.

The final issue of the Sd. Kfz 250/9 was fitted with the 2 cm Suspension Mount 38. To protect the roofless turret against hand-grenades, wire mesh was fitted over the roof aperture.

Basis for this anti-aircraft vehicle armed with the 2 cm Flak 38 weapon, was the medium, armored infantry vehicle (Sd. Kfz 251/17). Only limited numbers of these vehicles saw active service.

4.4.2 Medium, Armored, Half-Track, (Sd. Kfz 251)

Based upon the chassis of the light, three-ton, half-track tractor, this medium, armored infantry vehicle (Sd. Kfz 251) armed with a 2 cm Flak 38 cannon was primarily intended for air defense. In contrast to standard tractor configuration modifications were made to the radiator, steering-wheel, fuel-tank and exhaust system. The prefabricated armored superstructure was composed of the following main sections: front, centre, sides, floor and rear. All of which were constructed from armor plates either welded or riveted together. The frontal sections were angled obliquely rearwards to increase ballistic protection against small-arms fire. The superstructure was attached to the chassis using intermediate connecting fixtures. Front and centre superstructure sections covered both engine compartment and drivers cab. A protective guard plate shielded both steering linkage and shock ab-



Medium Armored Infantry Vehicle (Sd. Kfz 251/17)

sorbers agains possible damage. Centre and rear armored sections combined to make up the crew compartment, closed-off from the engine compartment by means of a steel bulkhead. The rear section consisted of the floor and side sections which protected important chassis members. Access to the crew compartment was via a double door in the rear section wall, the superstructure was roofless.

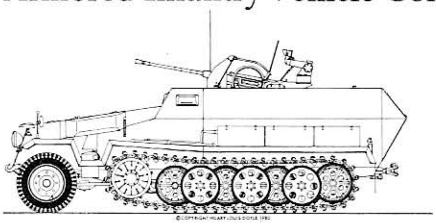
4.4.2.1 Medium armored half-track with 2 cm Flak 38 cannon (Sd. Kfz 251/17)

With the Sd. Kfz 251/17 the armored superstructure remained unchanged. Centrally mounted on a socket mount in the crew compartment was a 2 cm Flak 38 cannon. Traverse of this weapon was severely inhibited due to the narrowness of the crew compartment roof aperture. On-board ammunition totalled six hundred rounds.

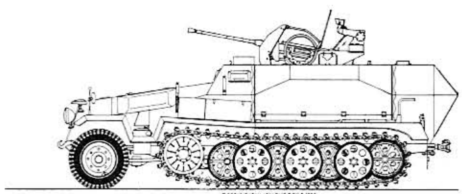
4.4.2.2 Medium armored half-track with 2 cm Flak 38 cannon (Air Force version)

The space limitations of the crew compartment were eliminated by this Luftwaffe Anti-Aircraft version, in merely widening the superstructure by hinging the armored side-walls to lower outwards. Thereby, the weapon could be traversed trough a full 360° and sufficient freedom of movement existed for the 2 cm Flak 38 gun crew to serve their weapon. The vehicle had a seven-man crew.

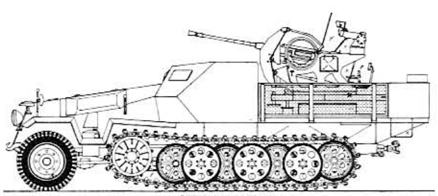
Armored Infantry Vehicle Comparisons



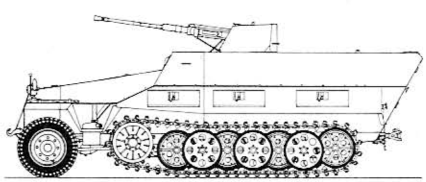
Medium (Sd. Kfz 251/17) Armored Infantry Vehicle.



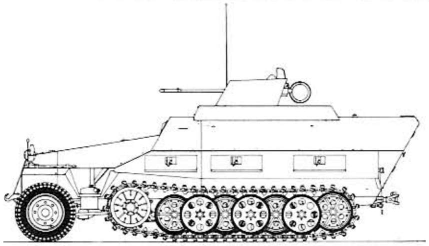
Medium (2 cm Flak 38). Armored Infantry Vehicle (Luftwaffe version)



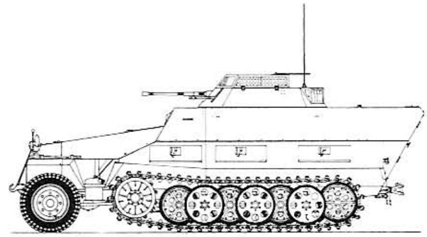
Medium (2 cm Flak 38) Armored Infantry Vehicle, Armored self-propelled gun carrier



Medium (2 cm Flak 38) Armored Infantry Vehicle, Suspension Mount

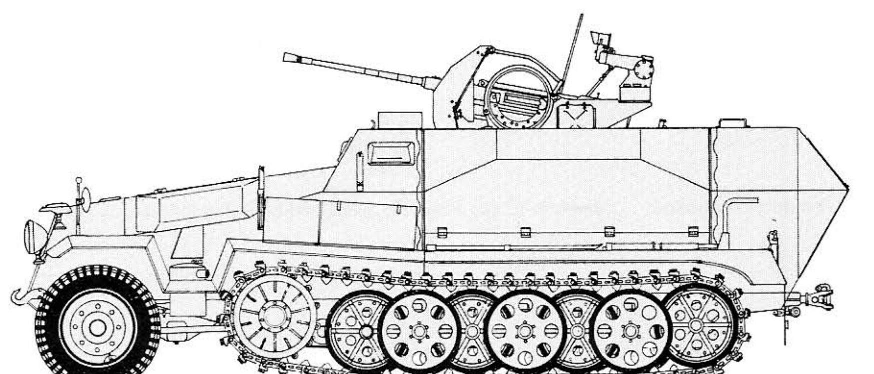


Medium (Sd. Kfz 251/21) Armored Infantry Vehicle



Medium (Sd. Kfz 251/23) Armored Infantry Vehicle

With the Luftwaffe version of the medium Armored Infantry Vehicle, mounting the 2 cm Flak 38, the armored, hinged sides of the superstructure could be lowered in order to provide a full 360° traverse for the weapon. The photographs show these side walls in both raised and lowered positions.



Medium Armored Infantry Vehicle (2 cm Flak 38) Luftwaffe version

4.4.2.3 Medium armored, half-track, with 2 cm Flak 38 as Self-propelled Armored Gun Carriage

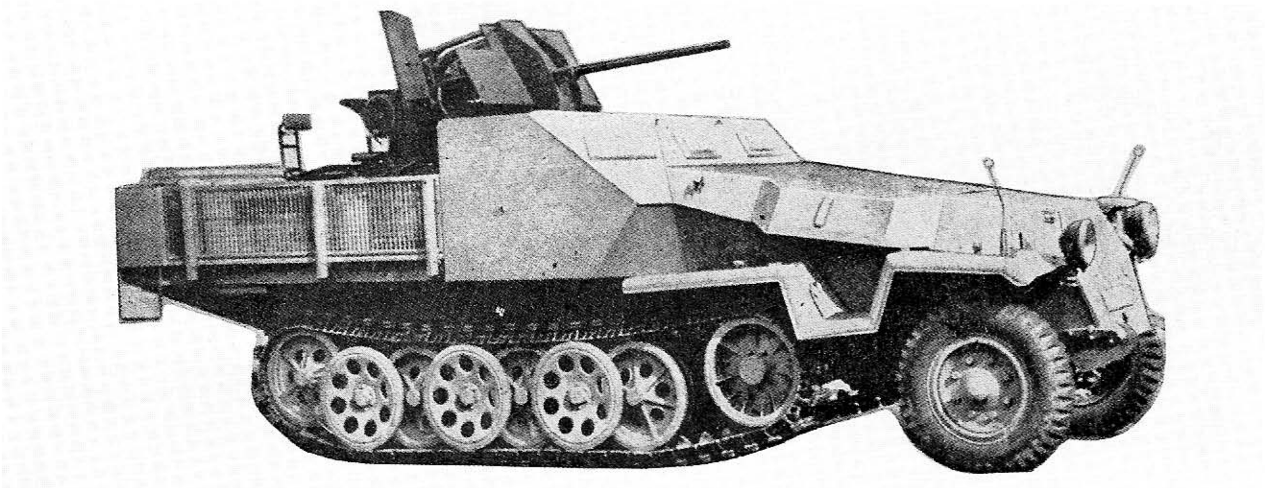
This vehicle was a derivative of the basic original vehicle. The centre and rear armored sections of the superstructure being removed and replaced by a gun platform. The surface area of this platform was increased by lowering the provisional side-

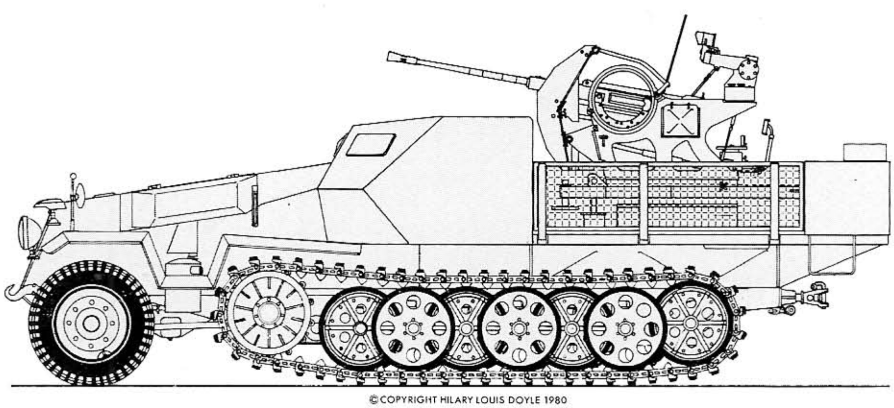
walls downwards and outwards 90°. Although this made more platform space available for the gun-crew, they were however left practically unprotected.

4.4.2.4 Medium armored half-track with 2 cm Flak 38 cannon with suspension mount

In 1944 the medium (2 cm) armored, infantry half-track with Suspension Gun mount was introduced into service. There were three major reasons for this, firstly the vehicles with the socket-type gun mounts could not effectively train their weapons at target. Secondly, the Luftwaffe solution was considered as being to complex in its construction. Thirdly the self-propelled version did not offer its gun-crew adequate armored protection. With the 2 cm Flak 38 suspension mount the weapon was cradled at a height which enabled both its traverse and elevation capabilities to be optimally applied. The weapon could also be used at negative fields-of-elevation. However, in combat against armored, Soviet ground-attack aircraft (IL 2) the 2 cm Flak 38 proved to be ineffective. Requirements for more effective air-defense tended in direction of systems having more barrels and larger calibers.

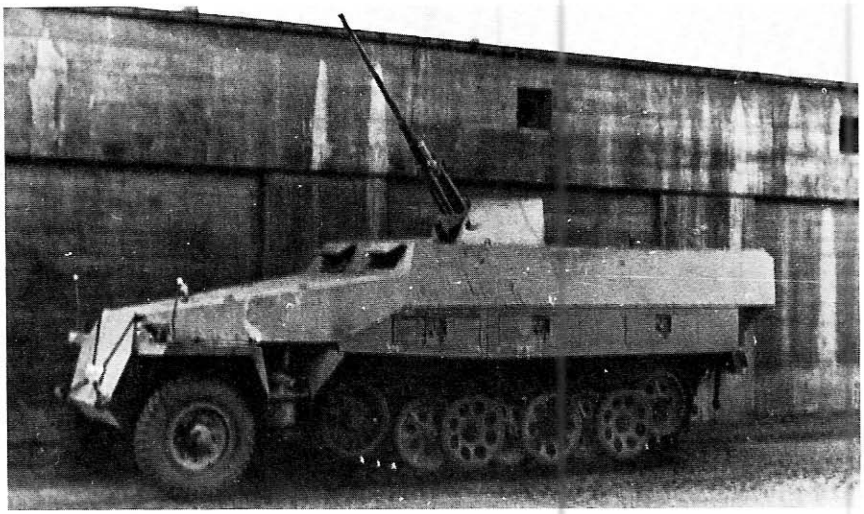
The armored, self-propelled gun carriage for the 2 cm Flak 38, incorporated both the frontal section and operational controls of the medium armored infantry vehicle. The gun-crew however remained unprotected.

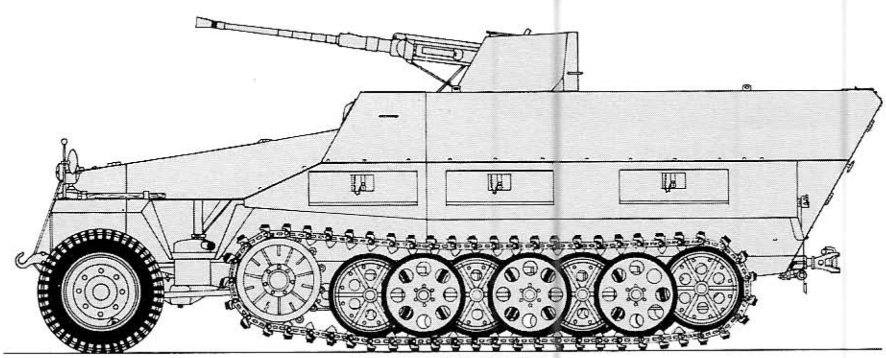




Medium armored infantry vehicle (2 cm Flak 38) – armored self-propelled gun carrier

Medium armored infantry vehicle, with 2 cm Flak 38 in a swivel mount. This facilitated lateral over board firing even at minus weapon elevations. This vehicle did not enter service until the last stages of the war.





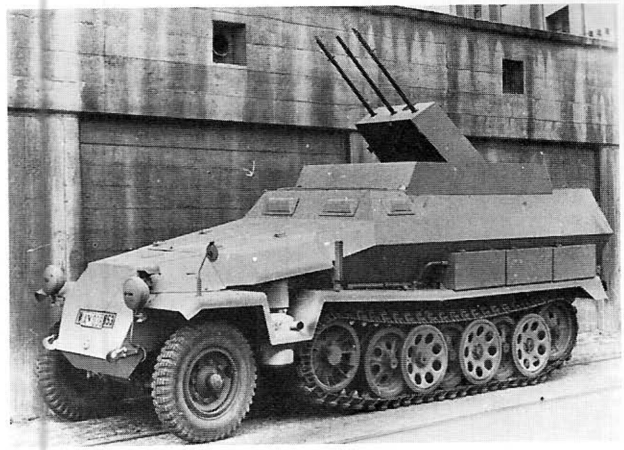
Medium armored infantry vehicle (2 cm Flak 38) with swivel gun mount

4.4.2.5 Medium armored half-track with triple 1,5 cm/2 cm heavy anti-aircraft machine guns (Sd. Kfz 251/21)

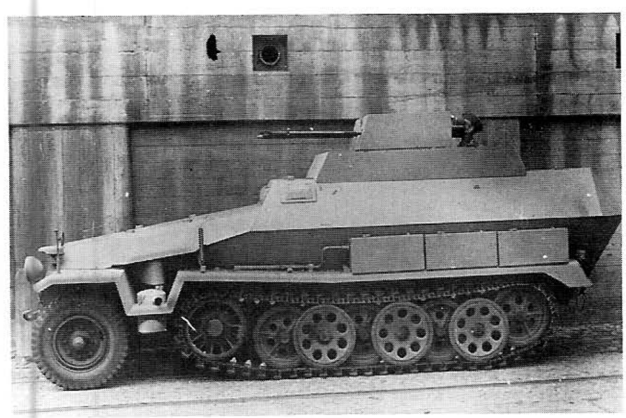
The uneconomical aspects of single weapons, due to both their low rates of fire and incapability to provide dense dispersion patterns at a target, was convincingly proven by the very low numbers of "downed" targets.

Because of this, from 1944 onwards, the armored infantry units (Panzer Grenadiers) were issued

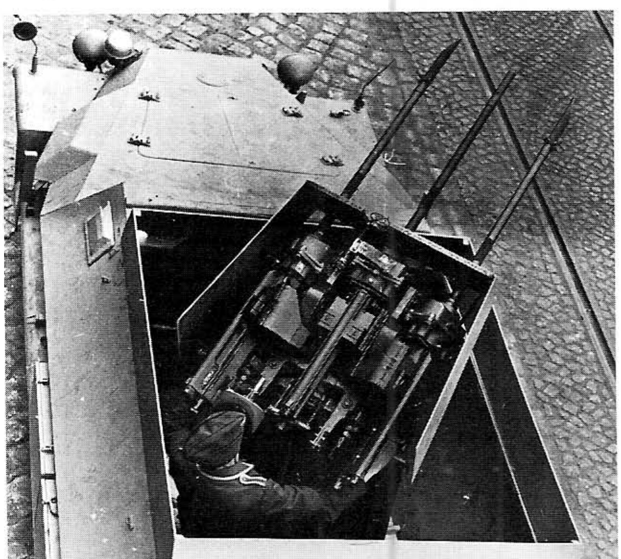
with armored, half track, air defense vehicles (Sd. Kfz 251/21). These vehicles were armed with triple, horizontally arrayed, 1.5 cm or 2 cm anti-aircraft machine cannon. Increasing numbers of successive vehicles were being armed with the 1.5 cm type MG 151/15 anit-aircraft machine guns as time progressed. These weapons could be traversed through a complete 360°. With the organisational structure of the 45th Armored Division for example, three such vehicles were assigned to each armored reconnaissance unit, another three to each armored infantry company. Improvement and modifications to the armor of these vehicles was frequenty observed, they were however purely field improvisations.



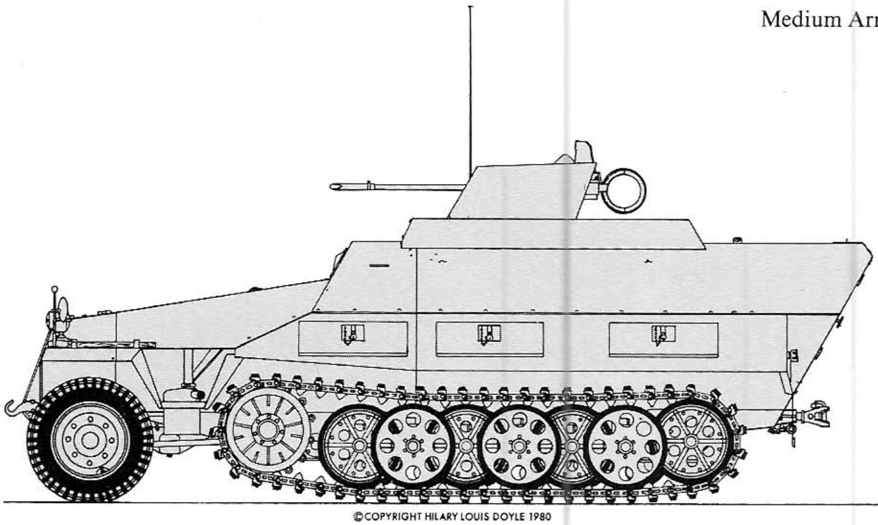
The large numbers of aircraft weapons which were available in the closing stages of the war were used for engaging both aerial and ground targets.
They were even fitted aboard armored vehicles. The photographs show a triple mounted version of the 2 cm, MG 151/20 on a medium (Sd. Kfz 251/21) armored vehicle.



This plan view of a Sd. Kfz 251/21 shows the limited space available within the fighting compartment of the vehicle. Occasionally, 1.5 cm barrelled (MG 151/20) weapons were also deployed in this manner.



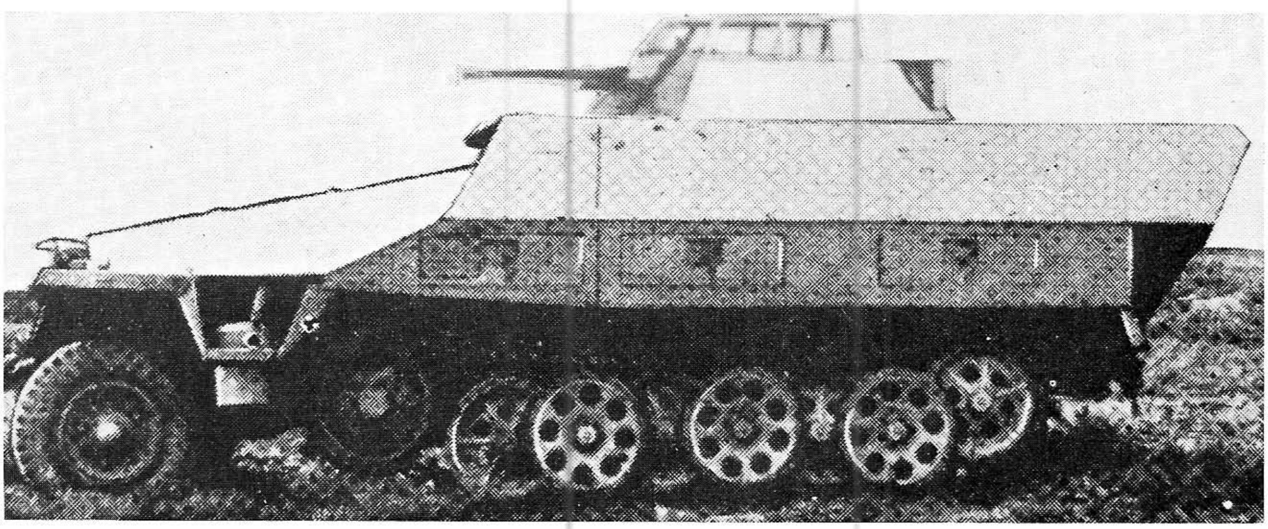
Medium Armored Infantry Vehicle (Sd. Kfz 251/21)



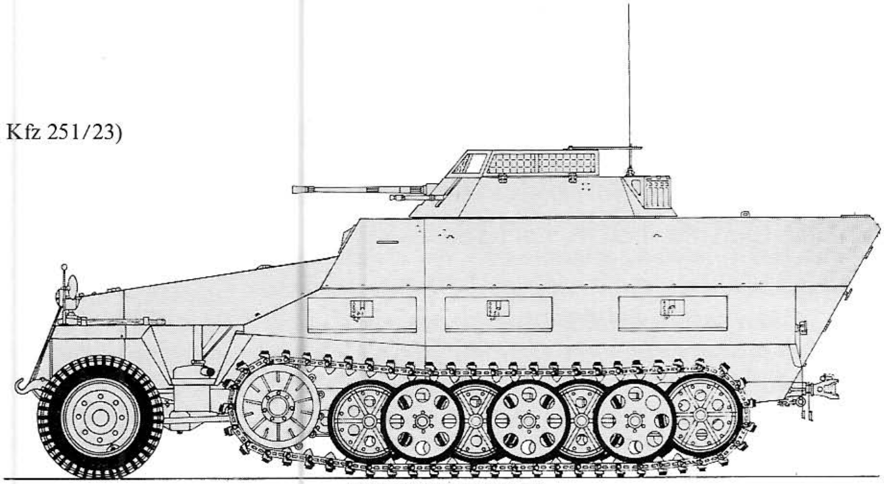
4.4.2.6 Medium armored half-track with 2 cm Flak 38 cannon and MG 42 machine gun in suspension mount (Sd. Kfz 251/23)

The turret with the suspension 38 gun cradle had already been widely adopted in many other combat vehicles. On the reconaissance tank 38 (Sd. Kfz 140/1), the light armored car (Sd. Kfz. 222) and its successor, the light armored half-track (Sd. Kfz 250/9), the heavy armored car (Sd. Kfz 234), was also to be using it. Being installed during the closing months of World War II, on the otherwise unchanged superstructure of the medium, half-tracked, armored infantry vehicle Sd. Kfz 251, this roofless turret carried both a 2 cm-Flak 38 cannon and a type 42 machine gun, facilitating the engagement of low-level attacking aircraft. Only limited numbers of this vehicle configuration were manufactured.

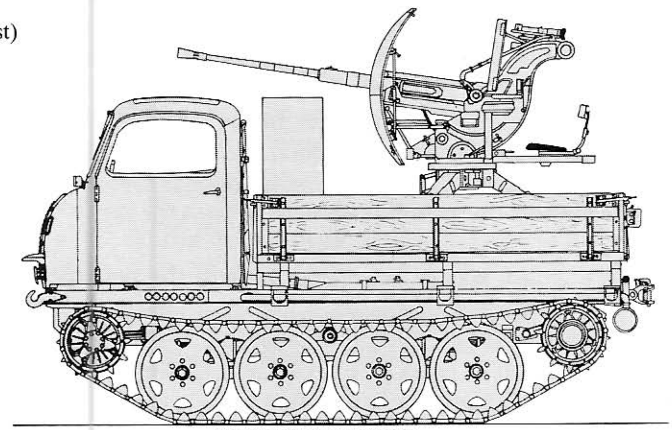
Medium Armored (Sd. Kfz 251/23) Infantry Vehicle with 2 cm Suspension Mount 38.



Medium Armored Infantry Vehicle (Sd. Kfz 251/23)



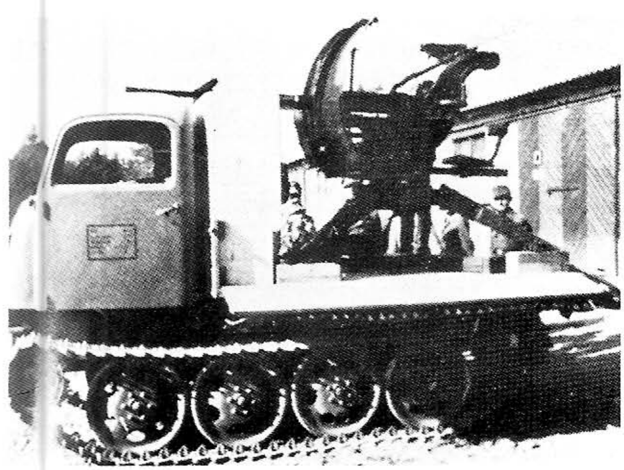
2 cm Mountain Flak 38, mounted on a (Raupenschlepper Ost) tracked Tractor, East



4.5 Tracked Tractor "Ost" (East) as Anti-Aircraft Gun Carriage

The first Mountain Anti-Aircraft Gun Battalion, established in the Summer of 1943, received the first tracked tractors "Ost", mounting 2 cm Flak 38's as self-propelled gun carriages. For manual transportation in the mountains these weapons could be dismantled into thirteen carriable loads and carried by the gun crew. Further mountain divisions established later, were each allocated one such anti-aircraft/anti-tank company. A company comprised in all twelve tracked Tractors "Ost", carrying such ordnance. For these 2 cm Flak 38 weapons a special mountain gun-cradle was developed, this same gun-cradle was also foreseen for introduction with the Flak Troop Escorts.

Tracked Tractors "Ost" were never introduced into service with the Armored Divisions.



Tracked Tractor East, as a makeshift self-propelled gun-carrier, fitted is a 2 cm Flak 38 in a mountain cradle. These vehicles were deployed in large numbers towards the end of the war

4.6 Self-Propelled, Anti-Aircraft, Gun Carriages and Tanks using Main Battle Tank Chassis

The success of the German armored columns early in the war was partially due to the very able ground support received from the Luftwaffe on the battlefield. This changed however during 1942, as the Allies began to assume aerial superiority in North Africa. First to suffer most severely being the naval and army supply forces. The armored units were next to follow, their inadequate air defense capabilities leading to large scale casualties and destruction being wreaked by enemy fighter-bombers. It is possible to ascertain from reports Field Marshal Rommel made at this time, that the aerial superiority which the Allies had at their disposal rendered impossible for his forces to achieve their operational objectives in Africa.

A similar fate was experienced later in the war by German Armored Units in Northern France, preparing to counter the Allied landings in Normandy. For example most of the tanks of the Armored Training Division were knocked-out by bombs, rockets and cannon-fire of enemy aircraft, not by enemy tank or artillery fire.

During World War II, two major occurrences shocked and directly influenced the German Army Ordnance Office.

Firstly: The debut of the first Russian, T34 Main Battle Tanks.
Secondly: The already mentioned, intensive Allied deployment of both fighters and fighter-bombers from 1942 onwards.

A Report of the Reich air Ministry, dated May 31st, 1943 makes the following comments concerning Air Defense.

"Enemy aircraft (tank hunter or destroyers) are currently attacking using either 3 cm or 3.7 cm caliber cannon (later increased to 5 cm), from ranges of approximately one thousand meters, at altitudes between one hundred and fifty and three-hundred meters. Attacking dive-bombers reach their lowest altitudes between twelve to fifteen hundred meters at angles of between 45° and 80°.

Only directed defensive firing brings any measure of success. Blindvertical upwards firing having only a distractive value and effect. On average between sixty and seventy rounds has to be fired in order to obtain one single hit, in the most favorable cases, thirty rounds can be reckoned with. For air defense the 2 cm caliber is the smallest considerable, the 3.7 cm caliber cannon being far better suited. Air defense weapon systems must have all round surveillance in order to effectively engage aerial targets travelling at speeds of up 500 km/h. Completely closed – in armored vehicles possessing all round armor protection are not therefore suited for air defense applications.
An armored group comprising ninety-six vehicles in combat formation, covers a surface of two kilometers wide by twelve hundred meters deep. Air defense using machine guns can only be carried out at ranges of up to six hundred meters. Against aircraft dropping loads of bombs, from altitudes of between one thousand and fifteen hundred meters even the 2 cm cannon will hardly suffice.
Air defense of the Soviet armored forces has been effective and led to our losing considerable material. Our own armored troops air defenses have also been improved and reinforced. Flak groups (anti-aircraft guns mounted on half-tracks) are receiving auxiliary SM (Siemens-Martin) steel armor to protect them and their crews against armor piercing munitions. Thereafter they are then being deployed to provide air defense for our armored forces."

Bases upon these reasons, both the Ordnance and Tank Commissions made the following decisions:

"The installation of anti-aircraft weapons in currently available main battle tanks does not appear to be possible. Application of the machine guns on these tanks, for self-defense against aerial attack in assembly areas and while on the move ist already planned. It is proposed that investigations be carried out to establish whether or not the chassis of the Mk IV Tank is suitable for conversion as an Anti-Aircraft Tank. Should it prove unsuitable it is planned to use the Panther chassis as an alternative solutions. With regard to armament the following possibilities exist:

Mounted on the Mk IV chassis
- ☐ *2 cm caliber, quadruple cannon*
- ☐ *3.7 cm caliber, mono cannon*

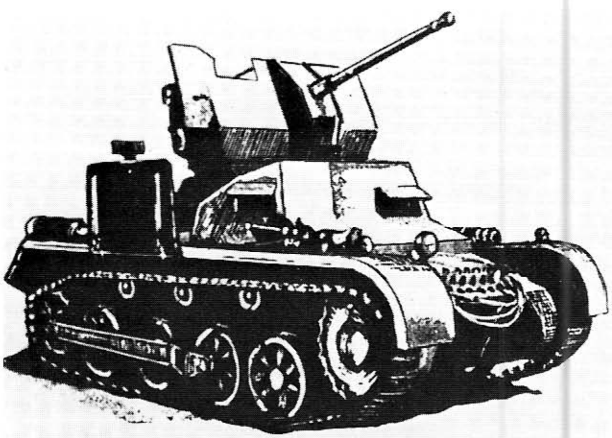
Mounted on the 'Panther' chassis
- ☐ *2 cm caliber, quadruple cannon (less mount)*
- ☐ *3.7 cm caliber, twin-or possibly triple cannon, after development has been completed.*
- ☐ *5.5 cm caliber, twin-cannon."*

In 1943, after Col General Guderian was appointed Inspector General of Armored Forces, more powerful German Main Battle Tanks, a direct response to the Soviet T 34, were already being manufactured. Guderian therefore saw his major obligation in pressing the air defense procurement requirements for anti-aircraft weapons systems capable of effectively protecting his armored forces in the field agains low-level aerial attack.
Dept. Wa Prüf. 6, of the Army Ordnance Office also opted in favor of developing a self-propelled gun-carriage for air defense applications. A decision which was in full accord with the earlier decisions which had been reached by both the anti-Tank and Artillery Commands. Wa. Prüf 6 foresaw existing light-Flak ordnance being mounted on the chassis of an existing, main battle tank. Moreover they planned that such gun stations would be contained within fixed armored housings in order to protect the gun-crews. In the meanwhile the Reich Air Ministries-Ordnance Master General-Air Defense Dept. (at that time fully responsible for all anti-aircraft developments) had established their own, excessively complex technical requirements for Flak systems mounted on main battle tank chassis. It was due to such complexity that delays occured in the development of the more simplified anti-aircraft tanks being sought by the armored troops. The solution proffered by the Air Defense Dept. of the Ordnance Master General in 1943, due to the technical requirements which they had imposed was an overdimensional anti-aircraft tank configuration utilising the Mk IV tank chassis. Due to its proportions this vehicle was quickly nick-named "the Furniture Van" by the troops. Co. General Guderian totally rejected the Air Defense Dept., Ordnance Master General's complete proposal. He then repeatedly renewed his demands for a weapon system capable of effectively countering low-level aerial attacks against armored units while on the march or in action.

Supply convoys destroyed by Allied fighter bombers.

A system able to accompany armor on the battlefield, capable of being brought into action very quickly. In Guderian's own opinion, the only vehicle able to fulfill such an air defense role would an anti-aircraft tank with its weapons mounted in a turret. The mayor problem now was the establishment of such a new homogeneous weapon system, considering existing tank chassis and Flak ordnance. In 1944, in France however an armored regiment of the Waffen-SS did succeed in constructing such anti-aircraft tanks at their own initiative. Guderian began to exert the considerable influence he commanded in order to co-ordinate the efforts of Luftwaffe, Army and Waffen-SS with respect to the problem at hand. As a result, the further development of anti-aircraft tanks became the full responsibility of the Armored Forces Inspectorate (In. 6), commanded by Maj. General Bolbrinker. He in turn made sure that young, resourceful tank officers were extensively involved in the program. These were the officers capable of cutting unnecessary red-tape or other such obstacles, they were able to improvise simply and effectively, provide trend-setting, ideal solutions, see them through all their many phases – to pre-series production, using whichever materials they could lay their hands on. The extremely threatening developments on the Front in 1944 drastically impaired and hampered both new developments and production. In spite of this though, armored columns moving into action westwards, did so with vastly improved anti-aircraft weaponry.

An already in 1941 created makeshift solution incorporated the absolete Panzerkampfwagen I (A-version) chassis with the 2 cm Flak 38 as a self-propelled mount.

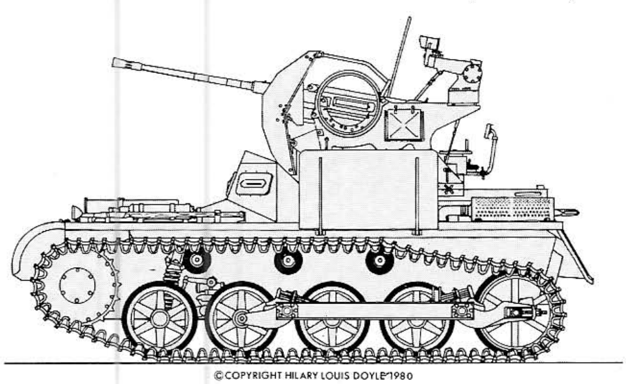


4.6.1 Self-Propelled, Anti-Aircraft Gun Carriages

4.6.1.1 Makeshift anti-aircraft tanks with 2 cm Flak 38 cannon mounted on Mk I, series A tank chassis

As early as 1941, three batteries of the 614th Anti-Aircraft Battalion, had each received eight, Mk I, Series A, Tank Chassis, each mounting a 2 cm Flak 38, cannon. This armament having been installed after removal of the standard turret and modification of the upper superstructure of the hull. This configuration was developed at the request of the Armored Troops Inspectorate (In. 6). Thereafter in accordance to an Army Ordnance Office, Wa Prüf 6, directive (signed by Col. Dr. Eng. Olbrich) the companies, Alkett, Berlin-Tegel and Daimler-Benz of Berlin-Marienfelde had been authorised to carry-out the necessary conversion work. By retaining both the armored front, upper-hull superstructure and the cannon armored shield a much improved, self-propelled, Flak system came into being. Particularly so, when compared to the earlier, unarmored, one-ton halftrack gun carriages. In addition, each company also received a further eight, unarmed Mk I vehicles as ammunition transports. Although con-

2 cm Flak 38 mounted on a Mk I Tank Chassis (version A)



Limited numbers of captured British Carden-Loyd-Gun Carriers, mounting either 2 cm Flak 30 or 38 cannon were used as self-propelled gun carriages. The photographs show these vehicle prior to, and after conversion.

siderable technical problems were experienced with these original 1935 vehicles in bad weather environments during the Russian campaign, in combat however they proved their competence. The last vehicles of this battalion were lost in 1943 at Stalingrad.

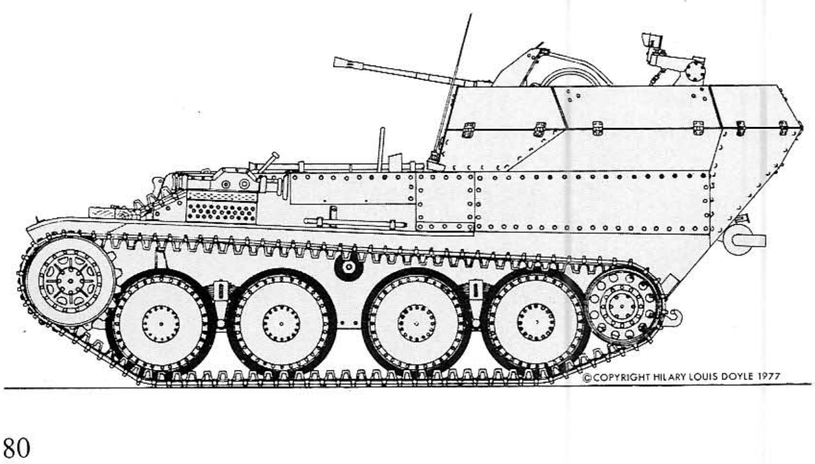
Some small numbers of British Carden-Loyd gun carriers which had been captured during the French Campaign of 1940, were adapted as gun carriages. These vehicles were fitted with either 2 cm Flak 30 or 38 Anti-Aircraft guns. They first saw action during the Balkans Campaign in 1941.

4.6.1.2 Anti-aircraft tank 38 with 2 cm Flak 38 cannon, mounted on the armored fighting vehicle 38 (Sd. Kfz 140) chassis

The proposed anti-aircraft tank development, based upon the Mk IV tank chassis which had been undertaken by the Luftwaffe's/Ordnance Master General/Flak/E Department could not be realised quickly enough. Therefore under an existing requirement of Inspectorate 6, the Bohemia-Moravia Machine Factory AG (BMM), of Prague, developed a further self-propelled gun carrier. By utilising the well proven, mid engined, series M, type 38 chassis, this company developed a self-propelled "Flak" gun carriage with a 2 cm-Flak 38 cannon mounted on its rear hull-section. This vehicle carried on-board, five hundred and forty rounds of HEI-T ammunition and a like amount of AP-T rounds.
The five-man crew of the vehicle was composed of the gunner (also doubling as commander) two loaders, radio-operator and driver. For gun-aiming, a ringed reticle sight and ground target $3 \times 8°$ telescope combination were used. The open-topped, upper superstructure made of 10 mm thick steel plate provided very limited protection for the gun-crew. A type Fu 5 UKW (VHF) radio set was installed for communications. Combat weight was 9.8 tons. Of the one hundred and sixty-two of these vehicles ordered in this configuration, only one hundred and fifty-two were completed due to their inadequate fire power. These were delivered over a period extending from November 1943 until February 1944. The remaining ten

A further interim solution on the way to development of a final anti-aircraft tank concept, was the Anti-Aircraft tank 38. A 2 cm Flak 38 weapon was mounted on the chassis of the type 38 tank (Sd. Kfz 140).

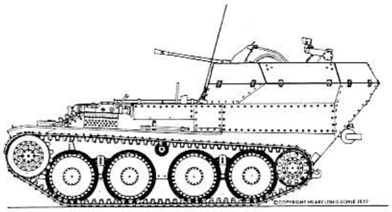
A total of one hundred and fifty-two of these vehicles were built, however their fire-power was no longer considered as being adequate. This vehicle mounted a single 2 cm Flak cannon.



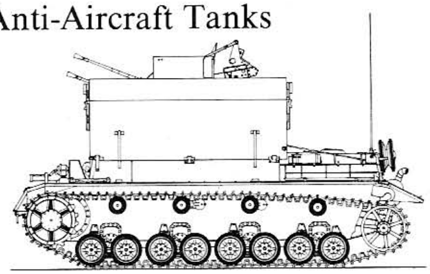
Anti-Aircraft Tank 38 (2 cm) (Sd. Kfz 140)

vehicles from this order were converted into self-propelled gun-carriages for the sIG 33 (15 cm) heavy infantry gun. These Flak Tank 38 vehicles were continually deployed until the war ended, it is interesting to note that in 1945, the HQ Company of the Armored Training Regiment still had more than twelve of these vehicles in serviceable condition.

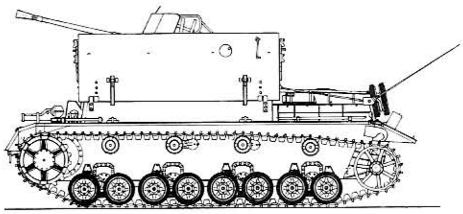
Comparisons between self-propelled Flak ordnance and Anti-Aircraft Tanks



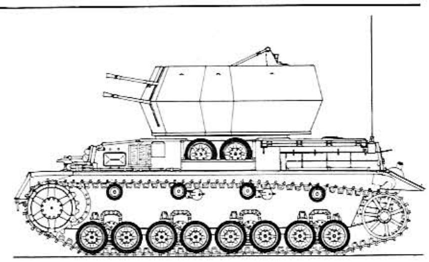
Anti-Aircraft Tank 38 (2 cm) (Sd. Kfz 140)



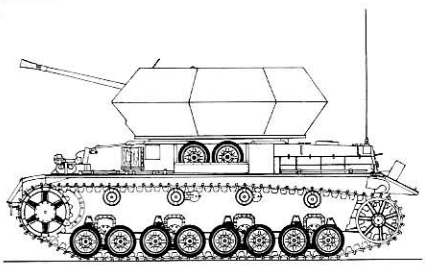
Self-propelled, Flak Cannon, "Furniture Van" (Möbelwagen) – Prototype



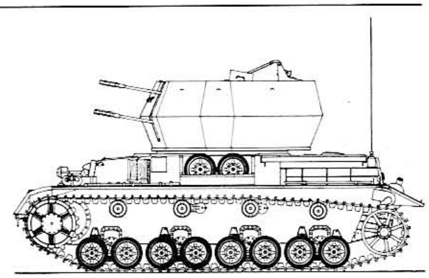
Self-propelled, Flak "Furniture Van" – Production Model



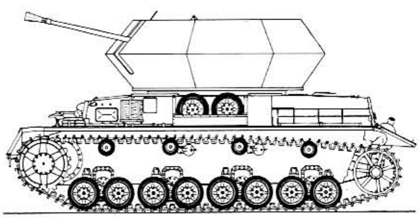
Anti-Aircraft "Whirlwind" Tank – Production Model (Wirbelwind)



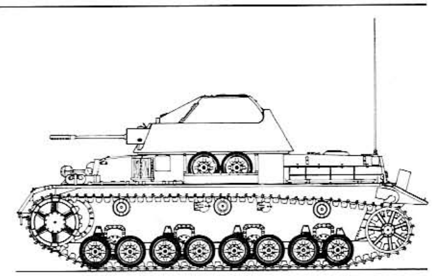
Anti-Aircraft Tank "East Wind" Production Model (Ostwind)



Anti-Aircraft Tank "Destroyer 45" – Prototype (Zerstörer 45)



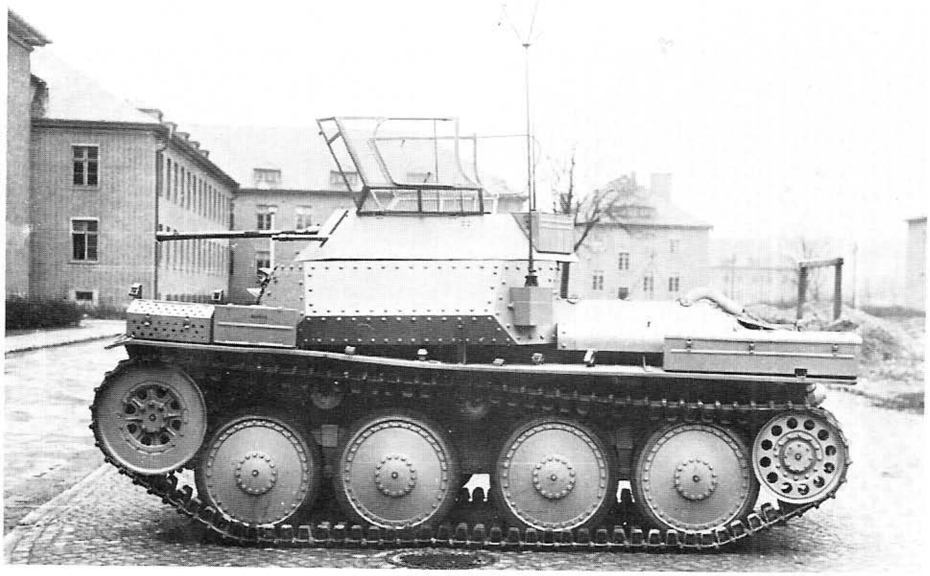
Anti-Aircraft Tank "Eastwind II" – Prototype (Ostwind II)



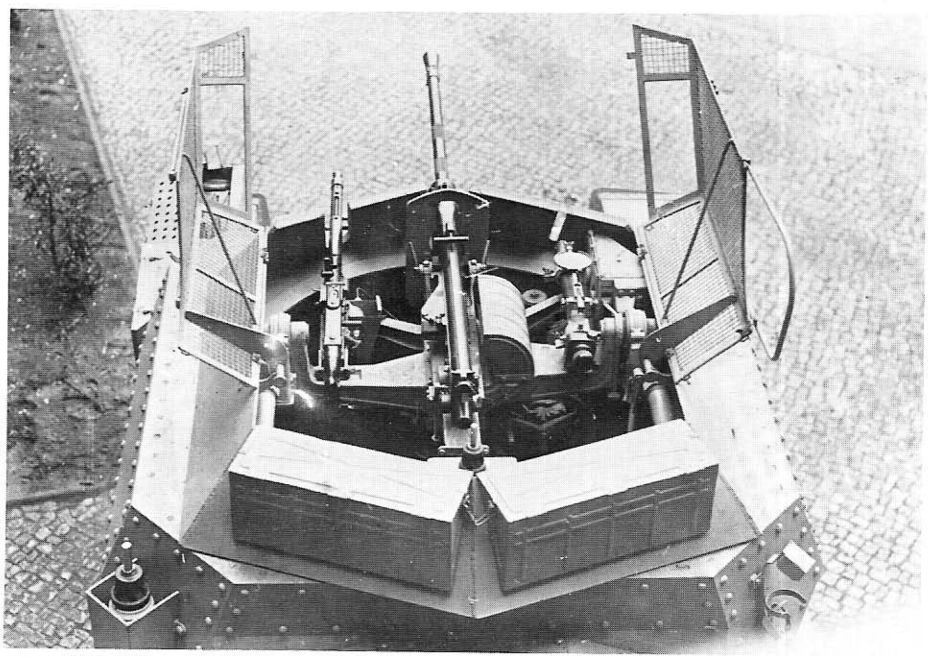
Anti-Aircraft Tank "Ball Lightning" – Prototype (Kugelblitz)

4.6.1.3 Reconnaissance tank 38 with 2 cm (KwK) 38 AFV cannon and type 42 machine gun, mounted on the armored fighting vehicle (Sd. Kfz 140/1) chassis

As a further derivative of the Anti-Aircraft Tank 38, in 1943, a total of seventy of these new vehicles were delivered to the troops. It was intended that these would replace the light, four wheeled (Sd. Kfz 222) scout cars and the (Sd. Kfz 250/9) light reconnaissance half-tracks. In this new configuration the Tank 38's (Pz. Kpf. Wagen 38) chassis remained unchanged. Whereafter the roofless, light scout-car's (Sd. Kfz 222) turret was mounted upon



During 1943, German reconnaissance units were issued with seventy, type 38 Reconnaissance tanks, a battle tank 38 derivative, mounting the armored scout-car turret. Both the 2 cm Combat Vehicle cannon 38 and the MG 42 installed in this turret could be deployed against aerial targets.



This photograph shows details of the 2 cm type 38 suspension mounting, as installed in the Reconnaissance Tank 38.

it. The 2 cm AFV (Kwk 38) cannon and type 42 Machine gun which were installed in this turret could both be used for engaging aerial or ground targets.

4.6.1.4 Mk IV Chassis, "Furniture Van" with Quadruple 2 cm – Flak 38 Cannon – as selfpropelled Gun Carriage

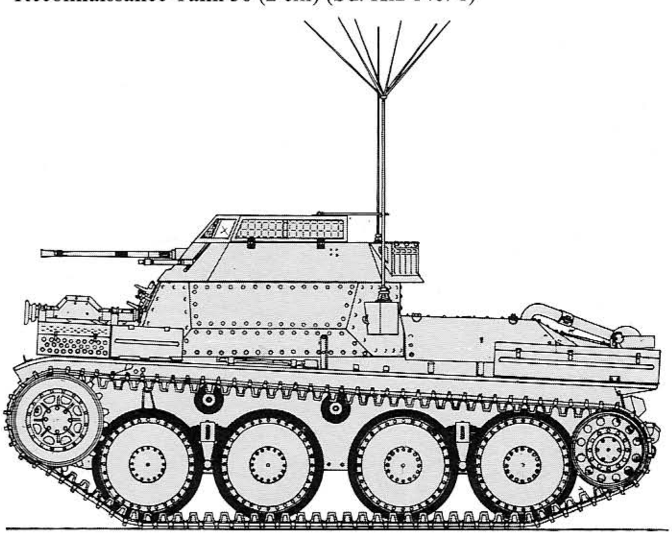
The indadequate fire-power of the Anti-Aircraft Tank 38 quickly led to an alternative solution being sought. Consideration was the given to utilising the chassis of the Mk IV Tank, which already existed in large numbers, as a potential carrier vehicle. Two air-defense solutions resulted from these considerations, a 2 cm Quadruple, Flak 38 concept or alternatively a single 3.7 cm cannon concept. On June 8th, 1943 the Ordnance Master-General/Flak indicated their approval to a proposal from Krupp for mounting a quadruple, 2 cm Flak 38 on the chassis of the Mk IV Tank. As stipulated in their contract, Krupp pesented their prototype vehicle on December 7th, 1943.

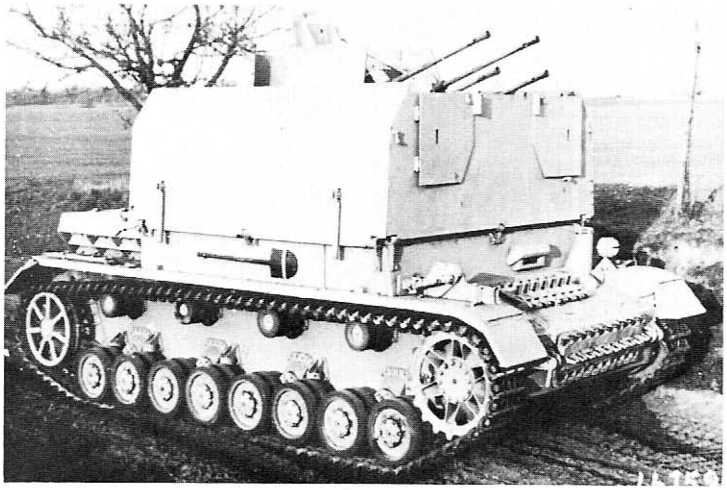
Parallel to this the Altmärkische Kettenwerk Co. (Alkett), Berlin presented a counter-proposal to Dept. Wa Prüf 6 of the Army Ordnance Office. The content of this counter-proposal did not include any measurable improvement to the "Krupp-Solution". A shortening of the platform sides walls, considered neccessary for optimising the new configuration imposed a penalising reduction of 350 mm in the height of the armored protection. The Wehrmacht High Command, who had rejected the light Flak/Mk IV Tank configuration on May 14th, 1943 demanded in October of the same year that the cost of such air defense system should closely be scrutinised. Major motivation for this demand being Dept. Wa Prüf 6 having requested the following additional equipment be supplied with the systems.

- ☐ Either a type 34 or 42 machine gun, with armor shield, mounted in the anti-aircraft 42 gun mount.
- ☐ Complete ammunition supply in "belt-sacks", two thousand rounds of MG ammunition (seven hundred rounds as "ready" ammunition).
- ☐ Entrenching tool sets, as standard supplied with the Mk IV Tank, with an additional pick and long-handled spade.
- ☐ Thirty hand grenades for "close-in" self-defense.
- ☐ Changing both the drivers and radio operator's hinged hatches to sliding covers for easier access/exit.

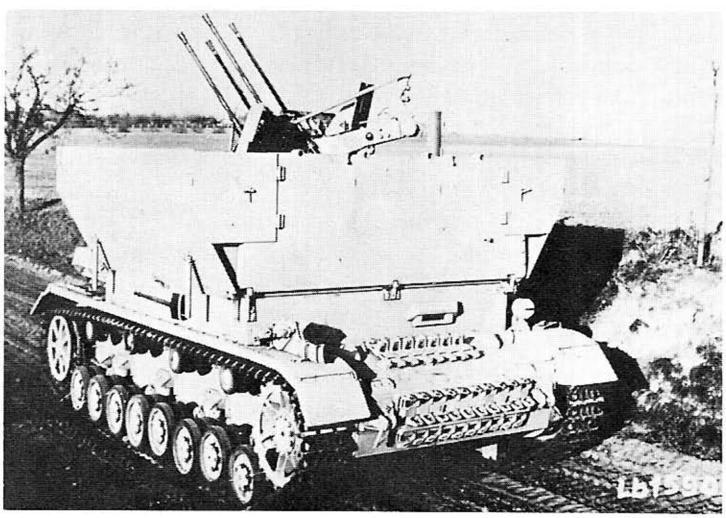
These requirements were far to unrealistic for providing a powerful, able anti-aircraft tank, for example, the proposed quantity of "on-board" ammunition for the 2 cm quadruple cannon was inadequate. A contract for the manufacture of a prototype vehicle was placed with the Krupp-Gruson Co. of Magdeburg-Buckau, with Krupp-Essen producing and delivering the new armored superstructure. The necessary Mk IV tank chassis were over-hauled army vehicles. Due to the three-meter high, bulky appearance of the new superstructure (see page 77 for comparison), the troops very soon nicknamed this vehicle the "Furniture Van". As the 2 × 10 mm thick, spaced armor sections of the superstructure had to be either partially or completely lowered in action, the gun crew were afforded very little protection. They were in fact no better of than they had been previously, in all-of the half-tracked gun-carriers. The vehicle had a five-man crew and a combat weight of 25 tons.

Reconnaissance Tank 38 (2 cm) (Sd. Kfz 140/1)





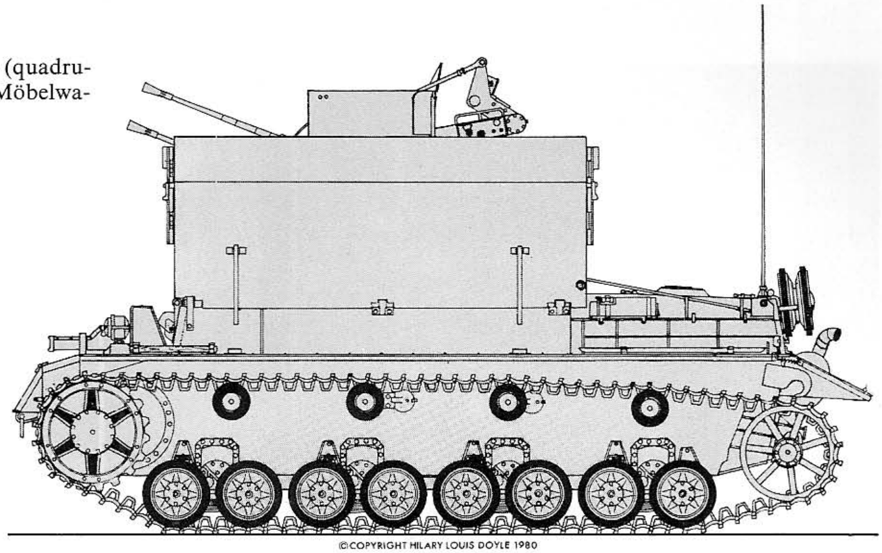
Only prototypes were built of the self-propelled carrier for the quadruple, 2 cm Flak 38, "Furniture Van" mounted on the Mk IV Tank chassis. The photograph shows the vehicle in "march" position.



The hinged plates attached to the protective armor plates were used to anchor the armored side walls at thirty degrees.

With all four side walls lowered to their horizontal positions, the gun-crew were totally unprotected at their weapon stations when firing.

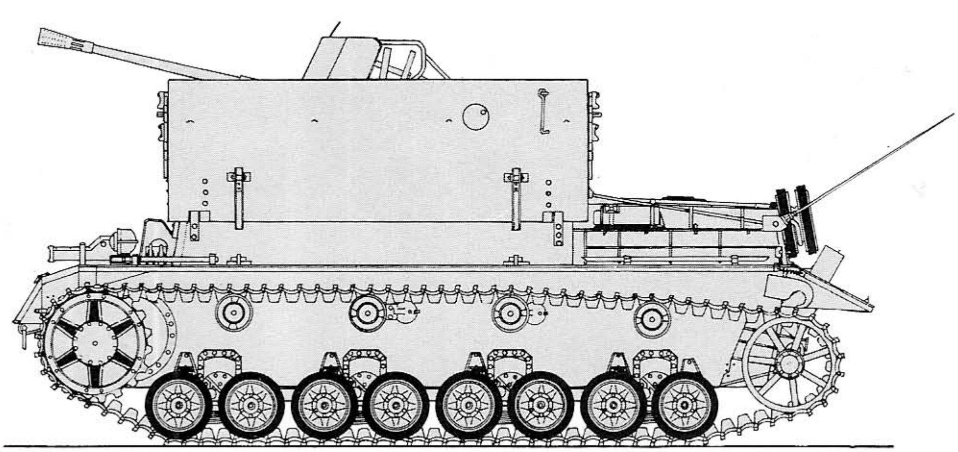
Self-propelled, anti-aircraft gun carrier (quadruple 2 cm Flak 38) "Furniture Van" (Möbelwagen) prototype



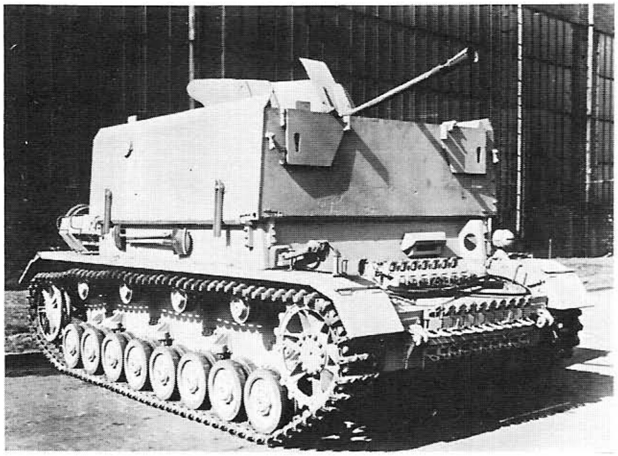
4.6.1.5 Mk IV Tank Chassis, "Furniture Van", with 3.7 cm, "Flak 43" Cannon as Self-Propelled Gun-Carriage

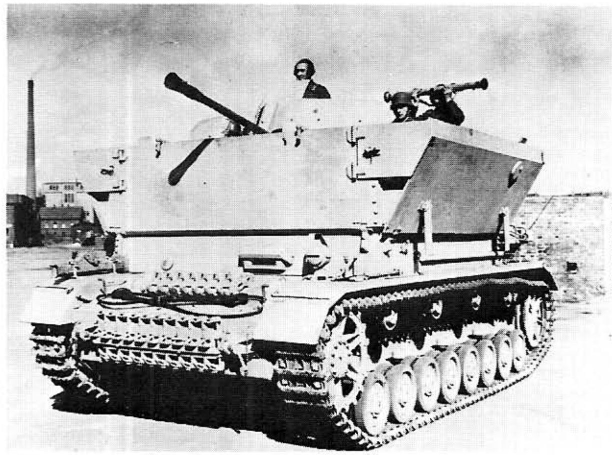
On January 28th, 1944 the Ordnance Master General/Flak decided that all self-propelled anti-aircraft gun systems mounted upon Mk IV Tank chassis, would be retro-fitted as standard issue with the 3.7 cm Flak 43 cannon. From March 1944, onwards, the companies of Krupp-Gruson, Magdeburg-Buckau and Deutsche-Eisenwerke, Duisburg, jointly re-fitted a total of twenty vehicles per month with the new weapon. Used as basic carrier vehicles were Mk IV chassis of the latest model series which had been major over-hauled. This chassis series was selected since sufficient spare-parts supplies were assured. The r.p.m. of the Maybach-Motors-HL 120-engine were increased by 200 r.p.m. to 2,800 r.p.m., its power output then being given as 272 H.P. Supply source for the hinged, lowerable sections of the superstructure was the Deutsche Röhrenwerke AG of Mülheim/ Ruhr.

By partially lowering the gun mounting down within the hull, the overall height of the vehicle was reduced. This self-propelled Flak gun carriage using the Mk IV Tank chassis hat either a six or seven man crew, on-board ammunition carried totalled four hundred and sixteen rounds.



Self-propelled, anti-aircraft gun carrier (3.7 cm Flak 43) "Furniture Van" – series production vehicle

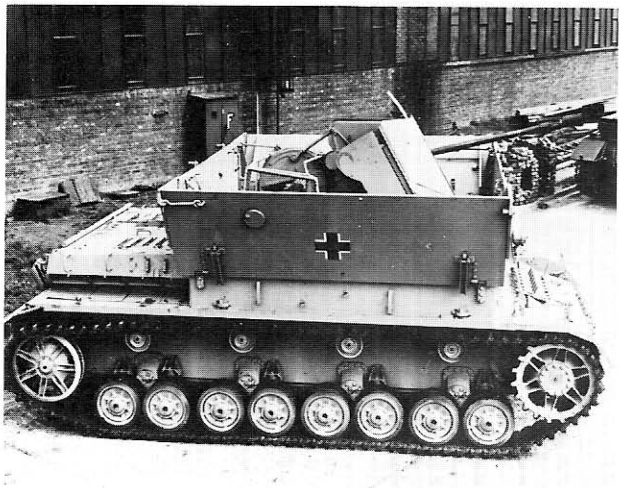




The 3.7 cm Flak 43 cannon mounted on a self-propelled gun carrier was manufactured as a series composed of two-hundred and five systems. These used the Mk IV "Furniture Van" superstructure. The photographs are works photos taken by the Deutschen Eisenwerke, Duisburg, and show the vehicle in both the "march" position and with the side walls at 30° angle providing the gun-crew with more space to move. The hinged anchor plates for setting the sides at 30° are shown in their original configuration.

With later models the hinged anchor plates were modified in order to provide additional protection for the gun-crew against ground fire.

A rear-view photograph shows the vehicle with its armored side plates closed Standing behind the gun-layer is the soldier using a range finder, whose ranging data was passed verbally to the gun-layer for manual setting.

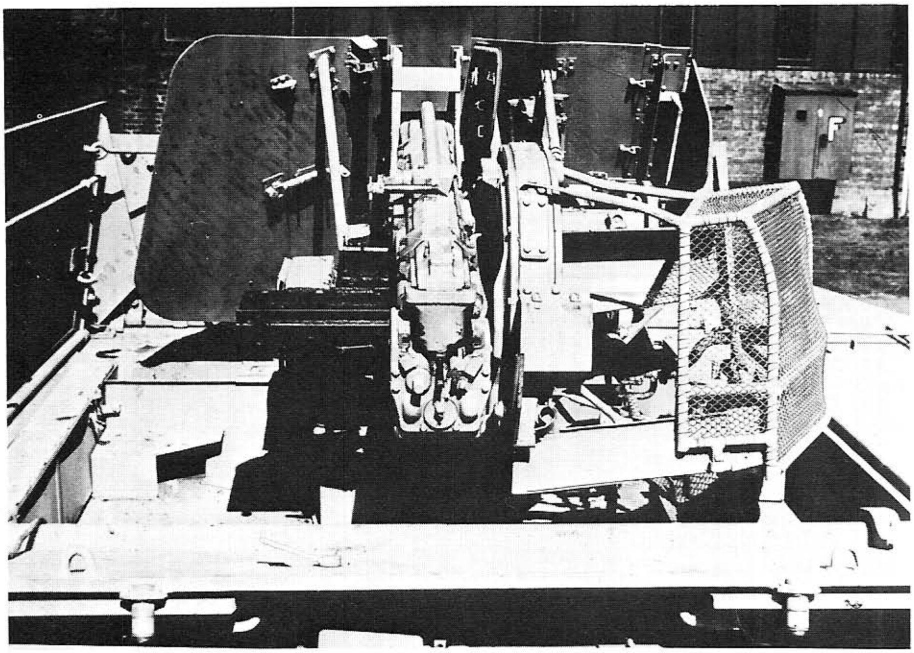


Photograph showing the vehicle with its armored side walls at the 30° position. This operation was necessary in order to increase the weapons field-of-traverse.

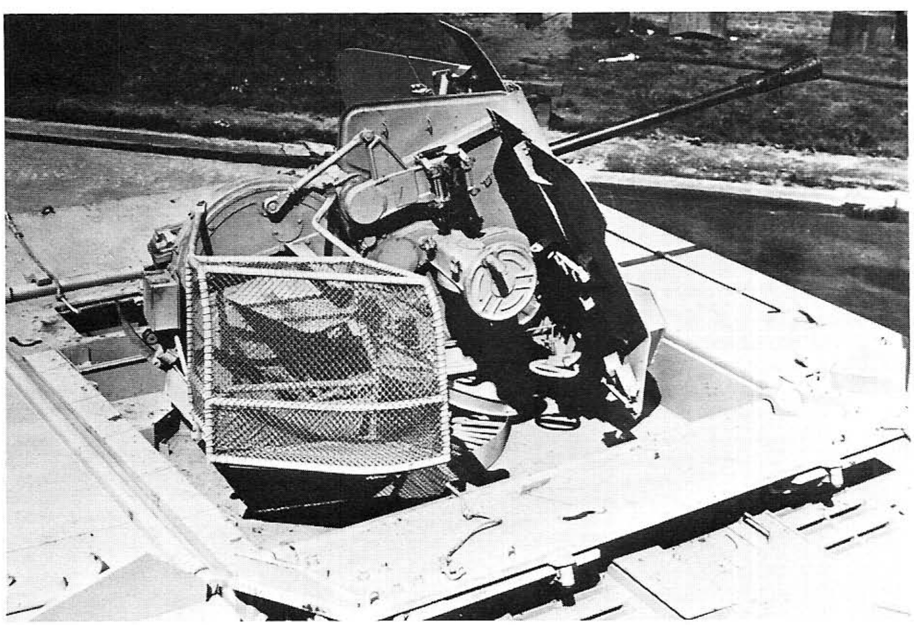
Upper Right: A rear view of the "Furniture Van" with its rear armored side plate at the 30° position.

Front view with the forward wall of the fighting compartment lowered horizontally. The Mk IV tank chassis was adopted almost unmodified.

The self-propelled "Furniture Van" gun-carriage, with differing gun-shields for the 3.7 cm Flak 43. All four armored side walls are at horizontal to facilitate full 360° weapon traversing.



Details of the 3.7 cm Flak 43 mounted in the "Furniture Van" superstructure. To the right of the weapon is a wire mesh cage for receiving the empty shell cases.



Together with a variety of other light, self-propelled "Flak" gun carriages this vehicle underwent trials on March 8th–9th 1944. Trials were carried out by the training and instructional staff of the Army-Anti-Aircraft Artillery, at the ranges in Oksbøl (Alsen Island), Denmark. These trials were observed by an audience of procurement officials as part of an elimination process for new weapon systems.

The 3.7 cm, Flak 43 cannon was manufactured by both the Rheinmetall and Dürkopp-Simson com-

panies. At a firing demonstration the weapon fired accurately and trouble-free. Noticeable however was the dense smoke which developed and the long tongues of flame exuding from the breech during firing (defleagration). The reasons for this being the war time gun-powder mixture available. Whereas the original lowerable sections of the superstructure had specified a 2×10 mm thick spaced-armor type construction, later production models used only single 20 mm thick armor plate for this purpose. Together Deutsche-Eisenwerke, Duisburg and Krupp-Gruson, Magdeburg built during 1944, a total of two-hundred and five, self-propelled gun-carriages equipped with the 3.7 cm, Flak 43.

4.6.2 Anti-Aircraft Tanks with Turret

The responsibility of developing and manufacturing anti-aircraft tanks as an "immediate solution", was transferred early in 1944, to the General Inspector of Armored Forces, Col. General Guderian. It was he who immediately commisioned the Armored Forces Inspectorate to draw up a report which fully expressed their views concerning the now volatile theme "Air Defense by Armored Troops". Whereby in their written response Inspecorate 6, rejected as totally unsuitable all air defense systems which had been developed up to that moment. The reason for their decision being that all such systems were totally unsuitable in conjunction with armored units. After which, the Armored Forces Inspectorate, represented by Col Mildebrath, requested that anti-aircraft tanks be developed possessing the following constructional features:

- ☐ Rotable, fully armored turret with a three or four-man crew
- ☐ Twin cannon (minimum armament)
- ☐ Adequate, on-board ammunition supply
- ☐ An overall vehicle height of less than three meters
- ☐ Radio equipment
- ☐ That the turret be smoothly faced, provide all-round visibility for both commander and gunner, be easily accessible for the crew and remain free of smoke and fume while firing.

Due to the problem which already existed with respect to the fumes generated during firing, the military requirement for a totally closed turret could not be realized up to 1945. The only alternative solution remaining the roofless turret, whereby the following features remained predominant:

- ☐ the roofless gun housing should remain a simple construction
- ☐ standard series-produced Flak gun-cradles should be utilised
- ☐ traverse drives should remain simple, furthered by lightweight turret/housing construction
- ☐ unobstructed removal of dense powder smoke and fumes
- ☐ good all-round surveillance facilities for both commander and gunner.

In order to realise these requirements there was no alternative to a roofless Flak turret, however with a much smaller aperture than any existing on the already available self-propelled gun-carriages. With this new turret configuration the field-of-elevation of the weapon was restricted from –5° to +85°.

Due to the heavy burdens imposed upon German industry to manufacturing war machinery, they were incapable of series production of such "immediate solution" equipment. The military in contrast proved far more flexible in regard to their ideas and improvisations.

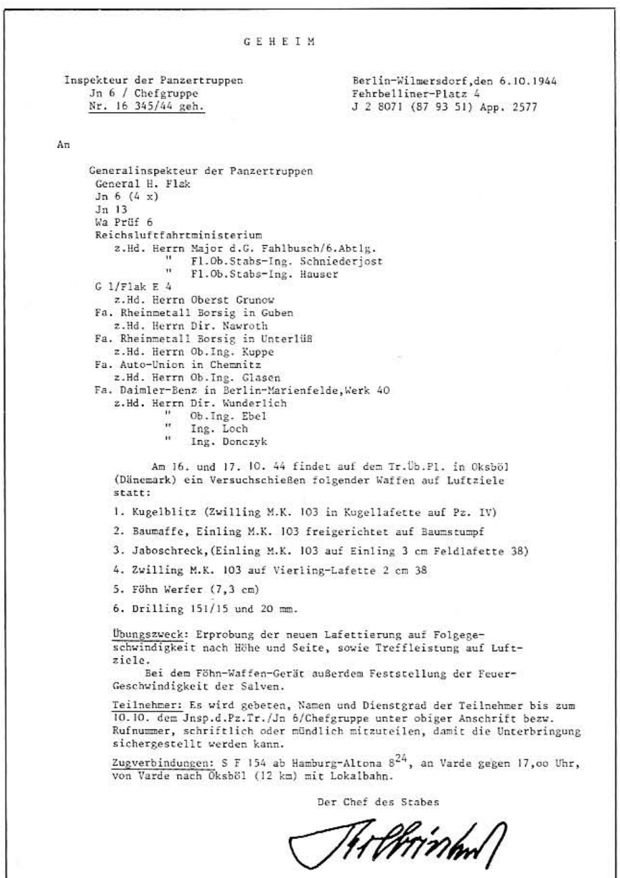
4.6.2.1 Anti-Aircraft Tank Development and Production by the "Ostbau-Sagan" Command (Sagan, Silesia)

The anti-aircraft tank requirements which had been established by Inspectorate 6, were to be realised by various "immediate" solutions. It was to this effect that the following order was issued to the Armored Replenishment Unit 15, stationed in Sagan-Silesia, who were made responsible for setting up the "Ostbau-Sagan" Command:

Inspector of Armored Forces/Insp. 6 Berlin-Wilmersdorf
No. 7406/44 Secret (III) June 8th, 1944
Subject: Establishment of "Ostbau-Sagan" Command.

To: Armored Replenishment and Training, unit 15. Sagan-Silesia.
Effective immediately, Arm. Repl. & Trng. unit 15 are to re-organize in order to allow the necessary working facilities being established for conversion and series production of Mk IV tanks with 2 cm-quadruple "Flak 38" gun systems. This high priority and urgent plan is to be given the utmost support at all times.
Importance will be attached to skilled personnel being utilised.
Soldiers from the Arm. Repl. & Trng. unit 15 workshop, together with soldiers selected by Inspectorate 6/III and other units are to be employed. This personnel will be formed into an independant unit, they will however remain under the jurisdiction of Arm. Repl. Trng. unit 15 as far as the economical and disciplinary aspects are involved. Their work will be carried out under the direct orders of Inspectorate 6. At no time is this unit to be drawn into serving within the Repl. Trng. Command. Unit Commander. Lt. Fitzner, Head of Production: Lt. Graf von Seherr-Thoss.

Sgnd. Mildebrath.



G E H E I M

Inspekteur der Panzertruppen
Jn 6 / Chefgruppe
Nr. 16 345/44 geh.

Berlin-Wilmersdorf,den 6.10.1944
Fehrbelliner-Platz 4
J 2 8071 (87 93 51) App. 2577

An

Generalinspekteur der Panzertruppen
General H. Flak
Jn 6 (4 x)
Jn 13
Wa Prüf 6
Reichsluftfahrtministerium
z.Hd. Herrn Major d.G. Fahlbusch/6.Abtlg.
" Fl.Ob.Stabs-Ing. Schniederjost
" Fl.Ob.Stabs-Ing. Hauser
G 1/Flak E 4
z.Hd. Herrn Oberst Grunow
Fa. Rheinmetall Borsig in Guben
z.Hd. Herrn Dir. Nawroth
Fa. Rheinmetall Borsig in Unterlüß
z.Hd. Herrn Ob.Ing. Kuppe
Fa. Auto-Union in Chemnitz
z.Hd. Herrn Ob.Ing. Glasen
Fa. Daimler-Benz in Berlin-Marienfelde,Werk 40
z.Hd. Herrn Dir. Wunderlich
" Ob.Ing. Ebel
" Ing. Loch
" Ing. Donczyk

Am 16. und 17. 10. 44 findet auf dem Tr.Üb.Pl. in Oksböl (Dänemark) ein Versuchschießen folgender Waffen auf Luftziele statt:

1. Kugelblitz (Zwilling M.K. 103 in Kugellafette auf Pz. IV)
2. Baumaffe, Einling M.K. 103 freigerichtet auf Baumstumpf
3. Jaboschreck,(Einling M.K. 103 auf Einling 3 cm Feldlafette 38)
4. Zwilling M.K. 103 auf Vierling-Lafette 2 cm 38
5. Föhn Werfer (7,3 cm)
6. Drilling 151/15 und 20 mm.

Übungszweck: Erprobung der neuen Lafettierung auf Folgegeschwindigkeit nach Höhe und Seite, sowie Treffleistung auf Luftziele.
Bei dem Föhn-Waffen-Gerät außerdem Feststellung der Feuer-Geschwindigkeit der Salven.

Teilnehmer: Es wird gebeten, Namen und Dienstgrad der Teilnehmer bis zum 10.10. dem Jnsp.d.Pz.Tr./Jn 6/Chefgruppe unter obiger Anschrift bezw. Rufnummer, schriftlich oder mündlich mitzuteilen, damit die Unterbringung sichergestellt werden kann.

Zugverbindungen: S F 154 ab Hamburg-Altona 8[24], an Varde gegen 17,oo Uhr, von Varde nach Öksböl (12 km) mit Lokalbahn.

Der Chef des Stabes

With a personnel strength of eighty men the new unit undertook the following work:

8th June 1944
Unit established by Armored
Forces Inspectorate 6, in Sagan-Silesia, under the auspices of unit 15, Armored Replenishment and Training. Dept. Wa I Rü (WuG 6) of the Army Ordnance Office ordered eighty "Whirlwind" (Wirbelwind) Anti-Aircraft Tanks. The prototype having been demonstrated in May 1944, by Verskraft of Kummersdorf.
24th July 1944
Trial firings with both the "Whirlwind" (Wirbelwind) and "Eastwind" (Ostwind) Anti-Aircraft Tanks at the Bad Kühlungsborn/Mecklenberg Ranges, on the Baltic Coast.
August 1944
The first batch of twenty-two "Whirlwind" tanks delivered.
28th to 30th Sept. 1944
Initial firing trials and demonstrations of the 3 cm – Flak 103/38 "Fighter Bomber Scarer" (Jaboschreck). "Eastwind" tanks undergo their baptism of fire while serving with an armored unit on the Western Front.
16th Oct. 1944
Successful demonstration of a new "Flak" weapon by Verskraft in Kummersdorf. "Ostbau" demonstrates the only properly functioning 3 cm "Flak", with an increased firing cadence (500 rounds per minute).
November 1944
"Eastwind II" developed (3.7 cm Twin, Flak 44, cannon). First prototype delivered in January, 1945.
18th–24th Nov. 1945
Primary firing trials of the "Destroyer 45" (Zerstörer 45), quadruple mounted 3 cm "Flak" 103/38 cannon. Demonstration of "Eastwind I" to Inspectorate 6 in Berlin-Wilmersdorf.
December 1944
The hundredth "Whirlwind" vehicle and thousandth "Panther driver seat" (Panther Hochsitz) delivered. Twenty-five HL 62 engines installed in "Luchs" armored cars. Steyr 2000 A truck equipped with the "Fighter Bomber Scarer" (Jaboschreck), (Gaubschat construction) and demonstrated at the Reich Chancellery, Berlin. A further hundred "Whirlwind" ordered by the Army Ordnance Office.
January 1945
Unit re-located from Sagan to Teplitz-Schönau, Sudetenland (German speaking Czechoslovakia).
Feb.–May 1945
Work commences in Teplitz- Schönau in co-operation with Deutsche Eisenwerke. By the time the war ends a further five "Whirlwinds" and twenty-eight "Eastwind I's" have been produced.

In parallel to the work taking place at Sagan, Ostmarkwerke of Vienna built the first two "Destroyer 45's" in December 1944. By January of 1945 a total of five "Destroyer 45" gun systems had been delivered to the troops.

◀ Written invitation to participation at trial firing of various anti-aircraft weapons at the firing range at Oksbøl (Denmark).

Production at "Ostbau", Sagan. Overhauled Mk IV tank chassis are being modified and fitted with anti-aircraft turrets.

The production program of "Ostbau" Command: left. "Eastwind" Anti-Aircraft Tank with 3.7 cm Flak 43 cannon. Centre: Self-propelled "Furniture Van" gun carriage armed also with the 3.7 cm Flak 43 weapon. Right "Whirlwind" Anti-Aircraft Tank armed with quadruple, 2 cm Flak 38 weapon.

The "Whirlwind" (foreground) and "East Wind" anti-Aircraft Tanks.

Lower Left: In the foreground, "East Wind" and "Whirlwind" Anti-Aircraft Tanks.

Anti-Aircraft Tanks from "Ostbau's" production being delivered. "Whirlwind" and "East Wind" Tanks prior to be handed over to the Army Authorities in "march" readiness.

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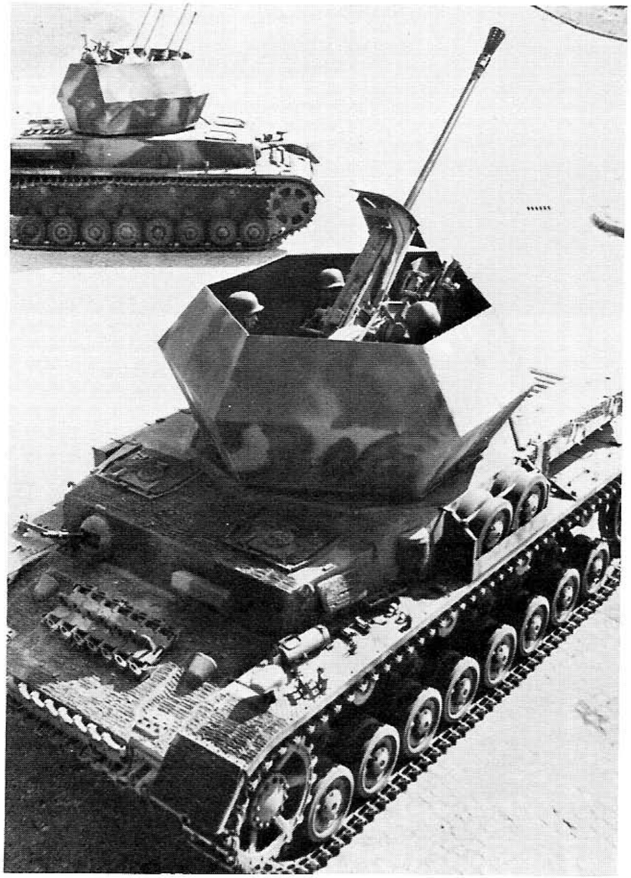
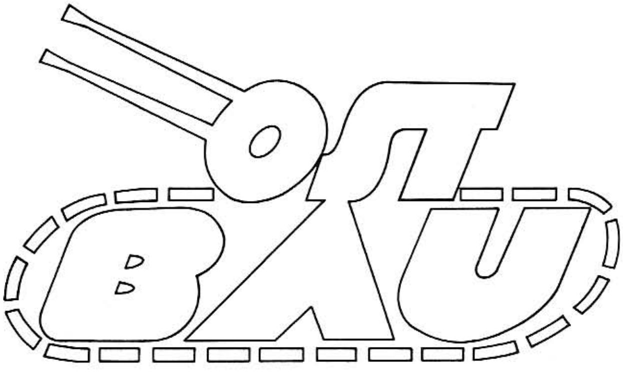




The "trade-mark" of "Ostbau" (East-Build) Command, organised by the Army High Command at Sagan/Silesia. "Ostbau" were charged with responsibility for producing anti-aircraft tanks.

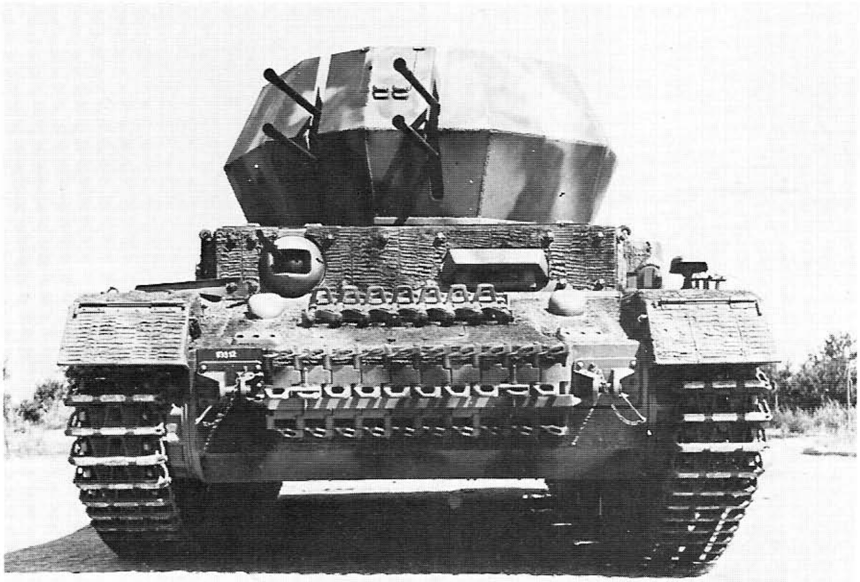
Self-propelled gun-carriers and anti-aircraft tanks at "Ostbau" Command: A "Furniture Van" (less weapons), alongside, an "East Wind" Anti-Aircraft Tank, above a "Whirlwind" Anti-Aircraft Tank.

4.6.2.2 "Whirlwind" (Wirbelwind) on Mk IV tank chassis with quadruple 2 cm Flak 38 cannon

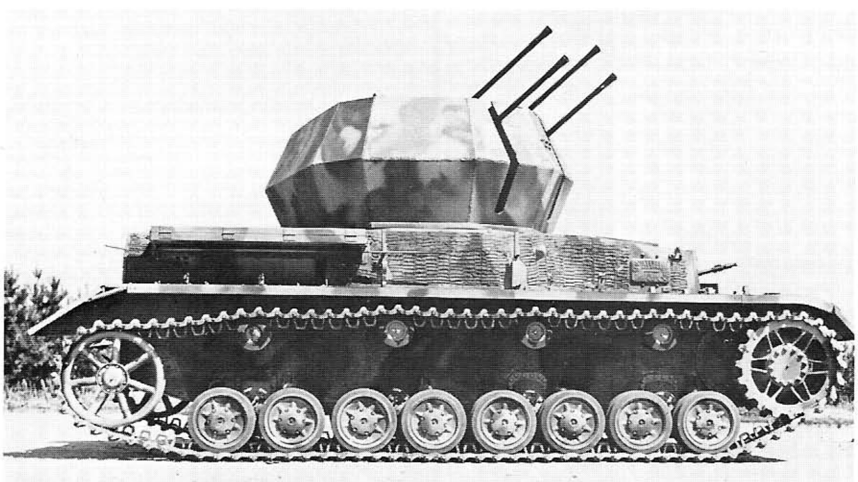
The "Whirlwind" Anti-Aircraft Tank with the quadruple, 2 cm Flak 38 cannon, housed in an adequately armored, roofless turret mounted on a Mk IV tank chassis could be described as being the first German Anti-Aircraft Tank. This vehicle suitably named the "Whirlwind", did in fact meet most of the requirements which had been established by (Insp. 6) the Armored Forces Inspectorate.

Sample prototype vehicles were built by Krupp-Druckenmüller in Berlin-Tempelhof together with Daimler-Benz, Berlin-Marienfelde constructing the turret superstructure. An all-welded construction, this turret was made from 16 mm thick armor plate, its base plate being almost double this thickness at 30 mm. Due to the pressure of that time the turret hatches which had originally been intended for the crew could not be produced. Therefore the turret remained a roofless structure, however by adept and skillful angling of the armor plate turret sections the size of the roof aperture was considerably smaller than those of the earlier self-propelled gun-carriages. As no suitable vehicle radar was available at that time unobstructed visual surveillance facilities were necessary. In order to prevent the possiblities of hand-grenades being tossed into the turret, hinged wire mesh sections could be raised and secured above it. A canvas tarpaulin served as roofing during inclement weather. The turret was mounted on the chassis of the Mk IV tank by means of a 1640 mm diameter turret ring. Stationed within the turret was a four-man crew composed of a gunner, next to him the commander and at each side of the gun mount, a loader. By partially lowering the gun mounting within the tank hull, the turret height was only 1050 mm, the overall height of the anti-aircraft tank being 2760 mm. Thereby the requirements established in Spring 1944 by Inspectorate 6 had been fulfilled (comparisons see page 89).

Initial slewing speed of the turret was 28°/s using a manually operated fly-wheel drive. Later a



The anti-aircraft tank turret known as the "Biscuit Tin" (Keksdose) had to remain roofless for fire control purposes. It was one of the best anti-aircraft tank solutions, appearing shortly before the war ended. The photographs show the "Whirlwind" Flak Turret, Mk IV Tank configuration (chassis no. 83312). Metal stowage boxes were mounted on both sides of the engine compartment, these were used for carrying spare barrels for the 2 cm quadruple Flak weapons.



hydraulic turret traverse drive, developed by the German Aircraft Research Establishement, Berlin-Adlershof, provided an increased turret "slewing" speed of 60°/s. An optical sight was provided for deploying the weapons against ground targets. The Inspector General of Armored Forces Col. General Guderian, authorised an initial conversion of fifty Mk IV tank chassis into "Whirlwind" anti-aircraft tanks. These chassis being drawn from maintenance workshops for this purpose in order to facilitate the first series being built by "Ostbau-Sagan".

No further decisions were made regarding any additional conversions being undertaken until Mk IV tanks, under the command of the Supreme Commander, West had been returned to Krupp-Druckenmüller for major overhaul. Whereafter, on June 27th, 1944 the initial number of the Mk IV tank/2 cm – quadruple, Flak 38 conversions which had been requested by Inspectorate 6, was increased to a total of eighty units. According to protocol Inspectorate 6 requested the Army Ordnance Office, Wa I Rü (WuG 6/VIII) to supply to the "Ostbau-Sagan" Command, eighty overhauled

Mk IV tank chassis, eighty turret structures, forty-five tons of assorted steel and armor plate, together with one hundred and sixty traverse drive gears to facilitate a gear ratio modification to the traverse drives.

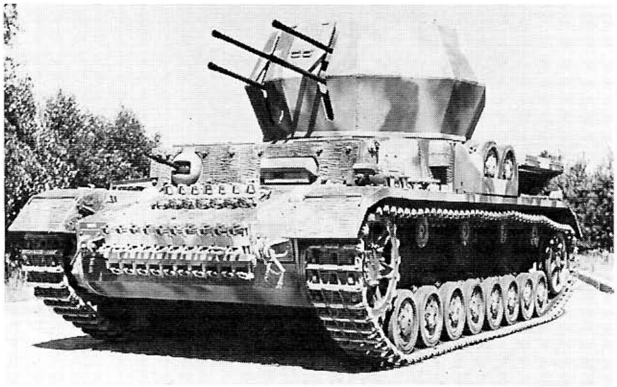
In general the work necessitated in producing a "Whirlwind" consisted of:

☐ Re-shaping the hull of the Mk IV tank
☐ Modifications to the quadruple gun configuration
☐ Manufacture of an installation kit for the guns
☐ Setting the turret on the chassis
☐ Painting and furbishing

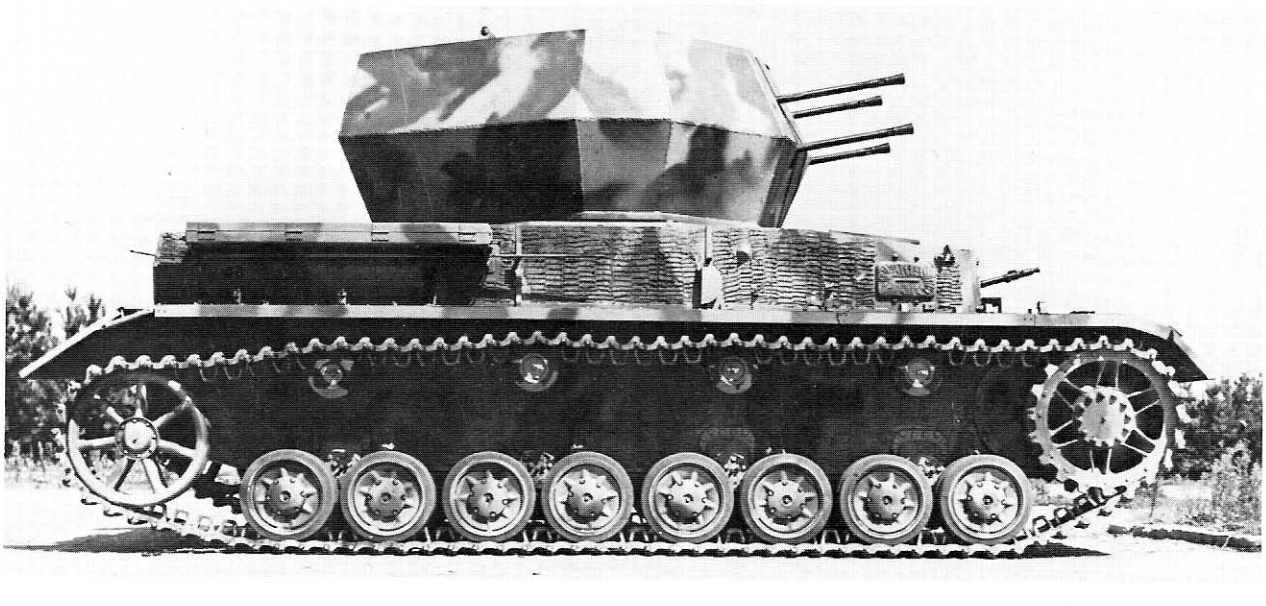
In detail the following modifications had to be made to either the weapons or chassis:

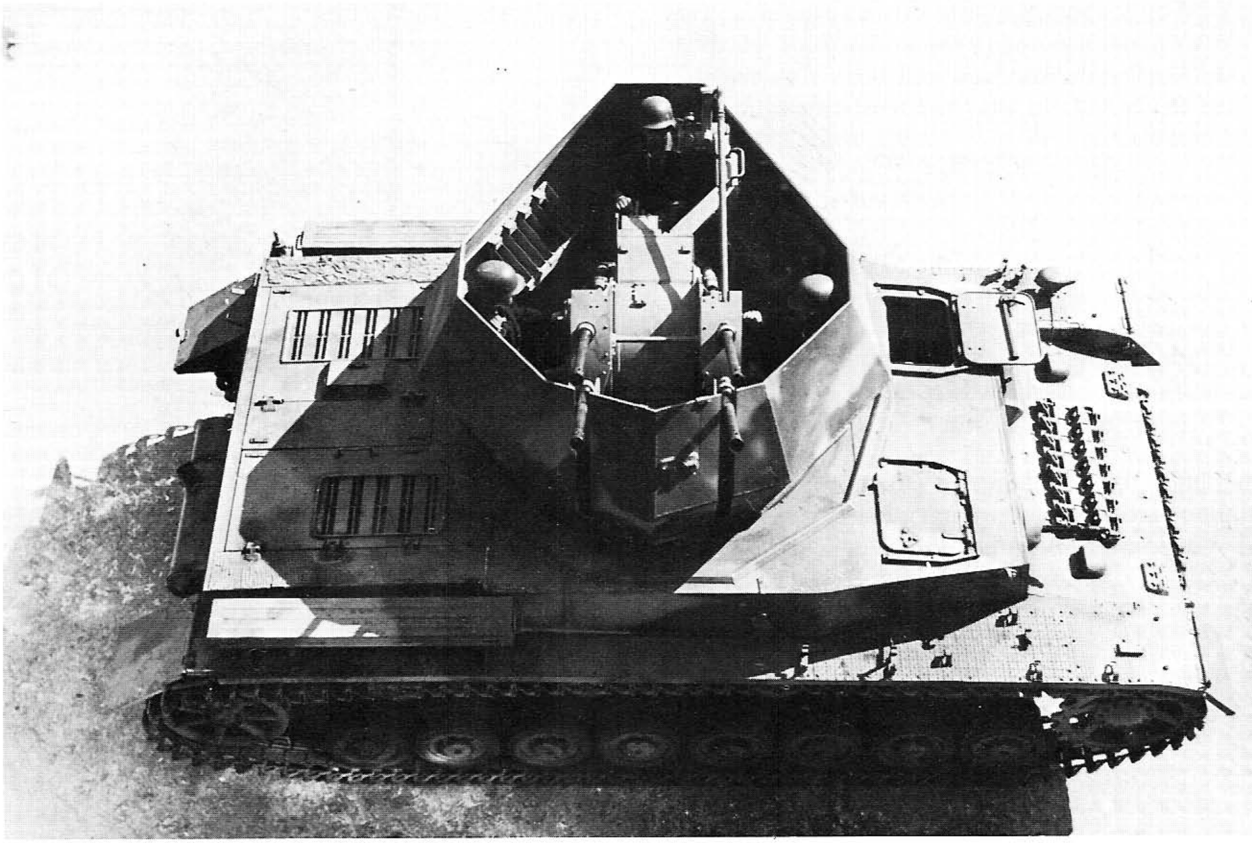
☐ Weapons: Shortening the used cartridge case collector box, no half-section gun-platform or loader seats, installing a setting ring on the turret base plate for positioning the slip-ring section.

☐ Chassis: Relocating both the manually operated fuel priming pump and inertial starter controls at the drivers station. Fitting decking over the fuel tanks. Partitioning-off the drivers and radio operators stations from the ammunition magazines. Installing the lower portion of the gun mount, consisting of two, double T steel sections. P 10, 2,200 mm long, a base plate 800×800×10 mm complete with fixing-lug and tapped holes for securing the upper gun-cradle assembly. Two pairs of laterally mounted retaining arms for carrying reserve gun barrel boxes.

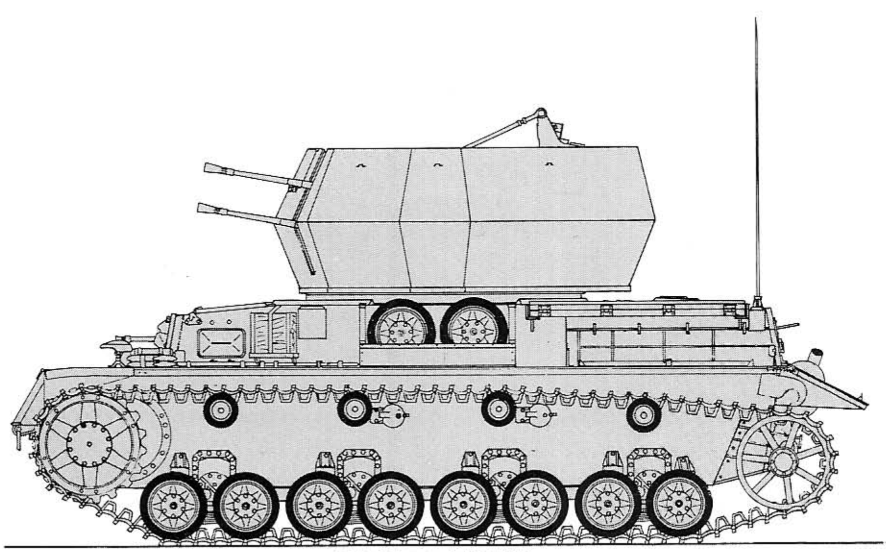


A "Whirlwind" Anti-Aircraft Tank mounting a quadruple 2 cm Flak 38 cannon.



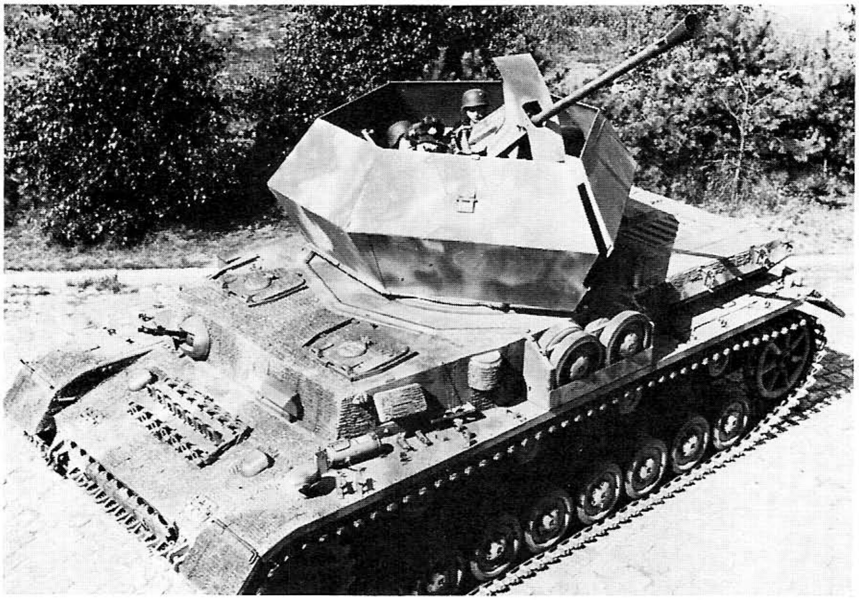


A "Whirlwind" Anti-Aircraft tank with turret at the 3 o'clock position and quadruple, Flak 38 weapons at maximum elevation. The gun-crew can be seen at their stations.



"Whirlwind" Flak Tank armed with quadruple, 2 cm Flak 38

A comparison between the "Whirlwind" (top) and "East Wind" Anti-Aircraft Tanks. The "Whirlwind" however lacks the "Zimmerite" coat of paint to protect it against magnetic mines.



The Ostmark-Werke GmbH, a subsidiary of the Hermann-Göring Werke in the Viennese Arsenal, delivered to "Ostbau-Sagan", gun-laying equipment and modified quadruple 2 cm, Type 38 gun mountings (the so-called Sagan Unit). Turret parts and components were initially manufactured by the Deutsche-Röhrenwerke AG at their Thyssen Works in Mülheim/Ruhr, after February of 1945 however this production was transferred to their Teplitz-Schönau Works. Famo of Breslau assembled the turrets. Final assembly and fitting of minor parts and accessories prior to acceptance by the Army Ordnance Office was all carried out by "Ostbau-Sagan".

A total of one hundred and five "Whirlwind" systems were produced.

The Anti-Aircraft Tank IV, "Whirlwind" armed with quadruple, 2 cm Flak 38 cannon, aboard the Mk IV tank (versions G and H) had a combat weight of twenty-two tons. With a total on-board ammunition supply of three thousand, two-hundred rounds of 2 cm-ammunition, in ninety boxes, this very first effective anti-aircraft tank was adequately munitioned. Laterally mounted at the rear of the tank were the containers for the four replacement cannon barrels.

Initial firing trial results of the "Whirlwind" Flak Tank had existed since July 1944. In all, during the firing trials involving the quadruple, 2 cm Flak 38 mounted on the Mk IV tank a total of two thousand, nine hundred and ninety-three rounds were fired, against aerial and ground targets. The closing evaluations by the Armored Forces Inspectorate make the following comment: "As a makeshift anti-aircraft tank solution the vehicle which has been demonstrated can be described as a very acceptable and functional piece of anti-aircraft ordnance."

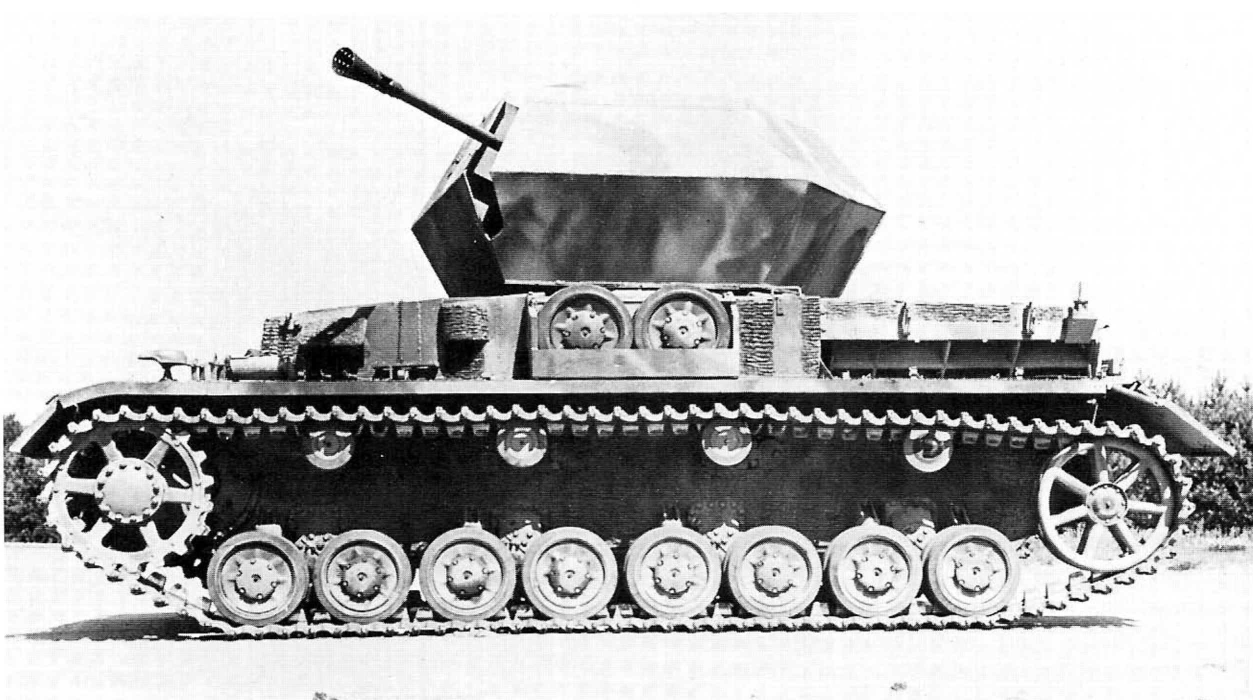
4.6.2.3 "Eastwind" (Ostwind) on Mk IV tank chassis with 3,7 cm Flak 43 cannon

On August 16th, 1944 the Inspector General of Armored Forces, Col. General Guderian, requested the Army Ordnance Office, Wa I Rü (WuG 6), via Inspectorate 6 that one hundred anti-aircraft tanks be built. These vehicles would utilise Mk IV tanks chassis (primarily version J), and would be armed with a single 3.7 cm Flak 43 cannon, in accordance with "Ostbau-Sagan" configuration. In order to facilitate such work proceeding the following equipment should be procured, or made available by alternative means,

- ☐ one hundred, overhauled Mk IV tank chassis
- ☐ one hundred, turret superstructures
- ☐ one hundred, Mk IV tank turret locking mechanisms
- ☐ one hundred, "Panther" battle tank periscopes

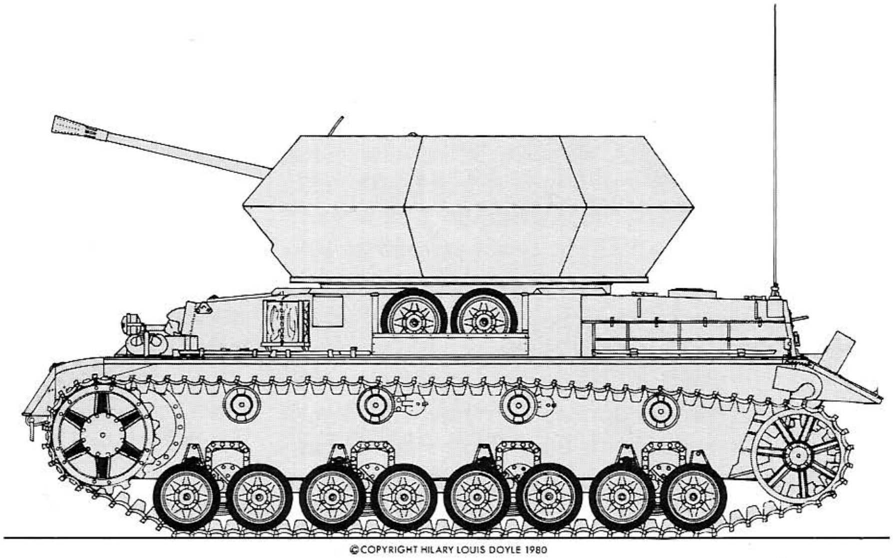
The gun-laying drives from the quadruple, 2 cm Flak were used to drive the turret traverse drives, traversing followed via the toothed turret ring of

The "Eastwind" Anti-Aircraft Tank also utilised late model, over-hauled Mk IV Tank Chassis.



An "Eastwind" Anti-Aircraft Tank mounting a 3.7 cm Flak 43. By the end of the war "Ostbau" Sagan had produced forty-three such units.

"Eastwind" Anti-Aircraft Tank with 3.7 cm Flak 43



the Mk IV tank. The rear portion of the turret was symmetrically laid out to provide the three-man crew with sufficient space for unrestricted movement. Manufacturing drawings and documentation were produced by "Ostbau-Sagan" these were then transferred to the Deutsche-Röhrenwerke, Mülheim/Ruhr factory for production.

"Ostmark-Werke GmbH, of Vienna delivering the turret traverse drives, drive-shafts and pinions. In accordance with directives issued by the Supreme Commander of the Luftwaffe, Ordnance Master General/Flak/E 2, the Josef Schneider Optical Factories, Bad Kreuznach manufactured a total of one hundred and fifty, Type ZF 1×40° telescopic sights. Dürkopp of Bielefeld building the necessary 3.7 cm, Flak 43 ordnance. "Eastwind" firing trials were very rapidly completed in July 1944, after only one hundred and twenty-three rounds had been fired. In the closing evaluation reports of Wa-Prüf 6 commenting on these trials stated "After resolving the method of traversing the turret and providing sufficient space within the turret to accomodate an additional crew member, the com-

mander, this makeshift configuration provides an extremely promising and viable solution. In September 1944, the mild-steel prototype which had been constructed by "Ostbau-Sagan" underwent its baptism of fire on the Western Front.

The "Eastwind" anti-aircraft was ready to enter series production by September 1944. Due to shortages of raw materials however, Deutsche-Eisenwerke AG's, Steel Industry Works in Duisburg, could not commence production until November 1944.

The order for these "Eastwind" anti-aircraft tanks armed with single 3.7 cm cannon on the Mk IV tank chassis, issued by the Army Ordnance Office, Wa I Rü 6 (Wu G 6), dated September 6th, 1944 read as follows:

- ☐ *Production of one hundred turret-shells and floor-plates, (SS-4902 – 0210-8818/44 [H] by Deutsche-Röhrenwerke AG, for one hundred, 3.7 cm "Eastwind" anti-aircraft tanks based upon the Mk IV tank chassis.*
- ☐ *Assembly (SS-4902 – 0210-8963/44 (H) by Stahlindustrie Duisburg of 100 Anti-Aircraft Tanks 3.7 cm "Eastwind"*

Both the "Whirlwind" and "Eastwind" vehicles were equipped with the type Fu 5 and Fu 2 radio sets and crew intercoms.

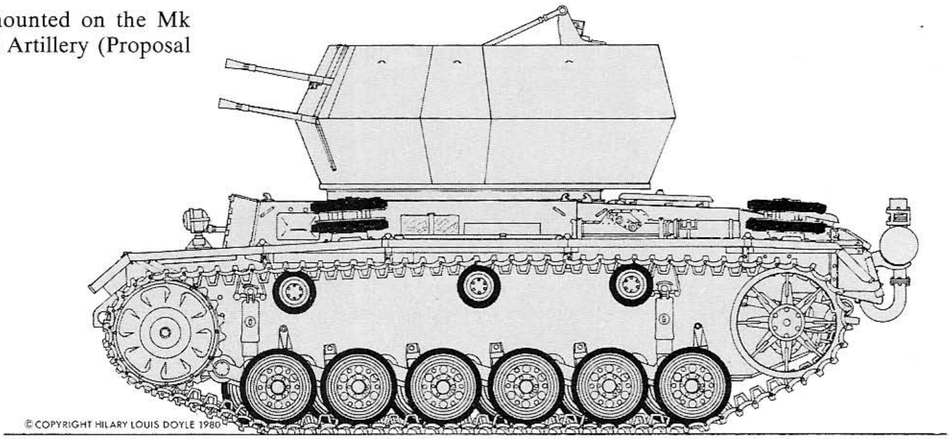
During series production of the "Eastwind" anti-aircraft tanks armed with the 3.7 cm Flak 43 cannon, the thickness of the turret armor was increased to 25 mm from November 1944 onwards. Although the "Eastwind" roofless turret was lower than that of the "Whirlwind" it was roomier for the gun-crew as only one loader was necessary. Eliminating the lower gun-mount portion of the 3.7 cm, Flak 43 had simplified the design considerably. The quantitiy of onboard ammunition carried totalled one thousand rounds.

4.6.2.4 Prototype "Eastwind" anti-aircraft tank with 3,7 cm Flak 43 cannon, on Mk III tank chassis for deployment with assault artillery

The Artillery Generals requested that some form of anti-aircraft Flak tank be made available for deployment with the assault artillery batteries in order to defend them against low-level aerial attacks. Unfortunately the greater majority of the assault artilleries self-propelled gun-carriages used the Mk III tank chassis. All of the anti-aircraft tank developments existing at that time had all been developed around the Mk IV tank chassis. Therefore under a directive issued by the Inspectorate of Artillery (Insp. 4) investigations were to be carried out to whether or not the new Flak turrets could be mounted on the Mk III tank chassis. Prior to this however in October 1944, officers from the Assault Artillery School-Burg had already visited the premises of Deutsche-Eisenwerke in Duisburg, in order to study the various anti-aircraft turrets already in production. They were to select the turret most suited for deployment with the assault artillery batteries. According to a letter from the Army Ordnance Office Wa I Rü 6 (WuG 6), dated January 3rd, 1945 Deutsche-Röhrenwerke were to deliver a closed floor version of the "Eastwind" turret to the Assault Artillery School – in Burg. The Army Ordnance Office, Wa I Rü (WuG 2) undertook the delivery of a 3.7 cm Flak 43 to the same school. One Mk III tank chassis/hull and two, 2 cm, quadruple, Flak 38 gun systems were made available to "Ostbau-Sagan" to enable their carrying out further investigative studies of this problem. After which "Ostbau-Sagans" Head of Production proposed that the "Eastwind Solution" as presented, ready for production by the Deutsche-Eisenwerke in Duisberg, be utilised.

The General in charge of Artillery requested the fastest possible delivery of ninety anti-aircraft tank turrets. As these structures had relatively low contingent weights (approx. 2 tons each) and assuming that the necessary 16 mm plate was readily available the order for production should be placed as soon as possible. Necessary chassis could be drawn from either of two sources, those already allocated to the Assault Artillery Batteries, or from overhauled stock. Frontal armor including turret race could be drawn directly from stocks kept by the maintenance workshops. By mid-March 1945 trials had been completed. These confirmed the possibility to mount the "Biscuit Tin" (code name for the "Eastwind" turret) on the Mk III tank chassis. The techno-logistic preparations carried out by

Prototype Anti-Aircraft Tank mounted on the Mk III Tank chassis for the Assault Artillery (Proposal with a Whirlwind Turret)

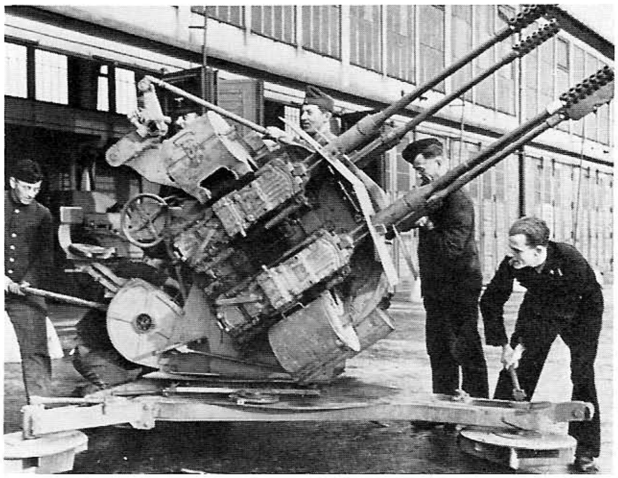


the Assault Artillery School were far enough advanced as to ensure the rapid completion of the turret superstructures after delivery, assembly on the tank chassis following quickly afterwards. Under the terms laid down in the "Emergency Armament Production Program", introduced by the Minister for Armaments and War Production, Albert Speer, on January 23rd, 1945 the material quota allotted for producing the turret structures was withdrawn by the Tank Commission. In spite of this, on March 17th, 1945 the Commanding General of Artillery, attached to the Army General Staff, requested authorisation be granted for completion of the eighteen partly built turret structures. Simultaneously requesting special dispensation be granted with respect to producing a further seventy-two turret housings, at a rate of twelve per month. This request prior to its dismissal received the laconic notation by the General Commanding Armored Forces as "eliminated by the deteriorating situation".

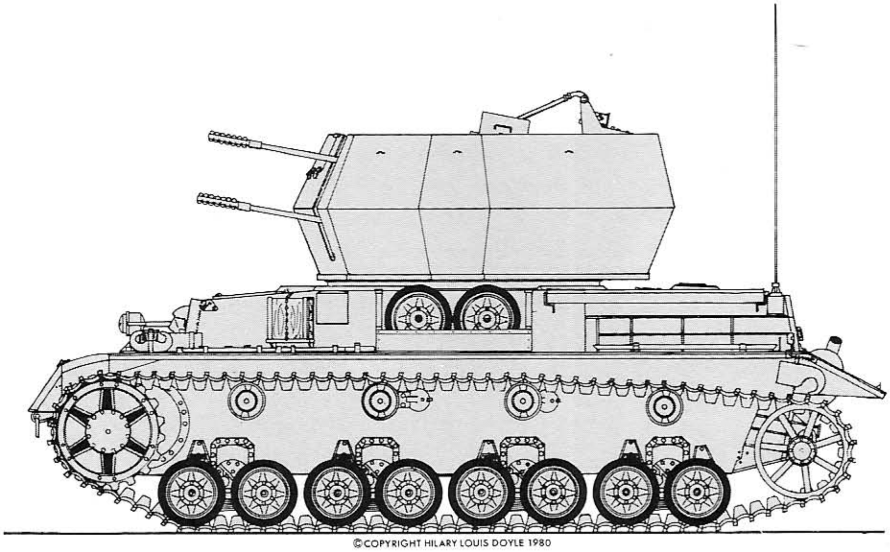
After which the Assault Artillery School, Burg near Magdeburg made the following proposal. They would establish their own workshops along similar lines to those of "Ostbau-Sagan" in Burg. The means of doing so being readily available, the constructive trials for the "Flakpanzer III" would be carried out by themselves. This expedient solution appeared to be the fastest possible way of ensuring that the assault artillery received the anti-aircraft tanks which they so desperately needed.

4.6.2.5 Prototype "Destroyer 45" (Zerstörer 45) anti-aircraft tank on Mk IV tank chassis, with quadruple 3 cm Flak 103/38 cannon

As a further development of the earlier Mk IV Anti-Aircraft Tank (quadruple 2 cm cannon), "Ostbau-Sagan" presented in November 1945 their new anti-aircraft tank prototype, the "Zerstörer 45". Its armament of quadruply mounted, 3 cm –

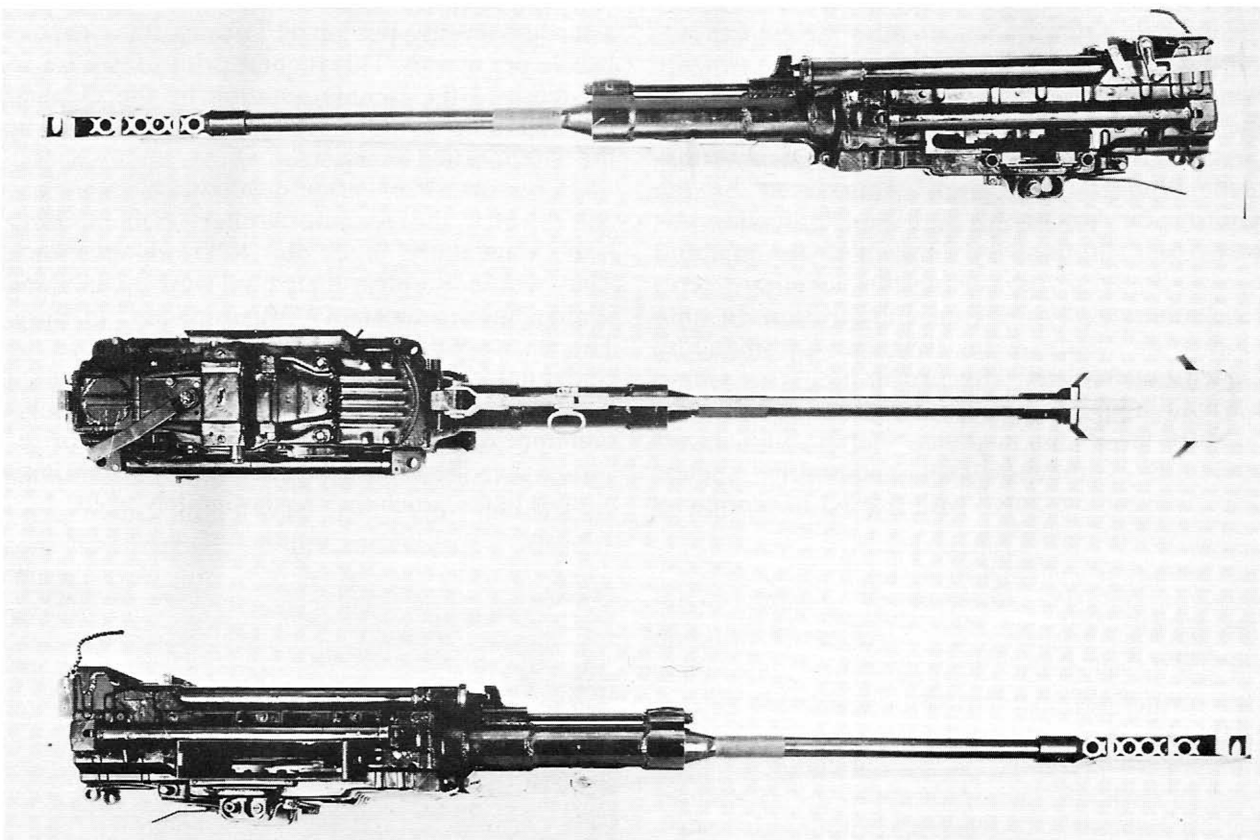


For the improved "Destroyer 45" Anti-Aircraft Tank, Ostbau-Sagan had anticipated installing the quadruple, 3 cm Flak 103/38, provisionally mounted on a "Furniture Van" chassis. To the far right of the photo, Lt Graf von Seherr-Thoss.



Prototype "Destroyer 45" Anti-Aircraft Tank, mounting a quadruple, 3 cm Flak 103/38

Details of the 3 cm Flak 103/38 cannon.



Type 103/38 cannon provided increased fire power. For firing trials this new armament was first mounted in a "Furniture Van" superstructure, although the final aims were to install it in the "Whirlwind" Turret. The distance between the upper and lower pairs of barrels was greater than that of the quadruple, 2 cm Flak 38 arrangement. In December 1944 two "Zerstörer 45" turrets were mounted on Mk IV tank chassis for further evaluation.

4.6.2.6 Prototype "Eastwind II" (Ostwind II) anti-aircraft tank on Mk IV tank chassis, with twin 3,7 cm Flak 44 cannon

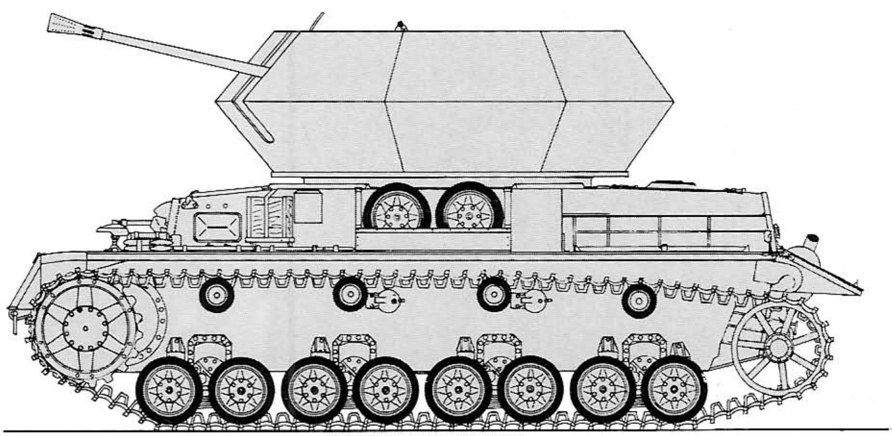
The "Eastwind II" prototype was developed by "Ostbau-Sagan", its turret remained similar in appearance to that of the "Eastwind I". Its armament however consisted of twin, co-axially mounted, 3.7 cm, Flak 44 cannon spaced 300 mm apart. Due to the layout of the cannon two loaders were necessary. The upper section of the gun-cradle was made and delivered by Gustloff-Werke, Suhl. The prototype being completed by "Ostbau-Sagan" in January, 1945 and then issued to the Armored Replenishment and Training Regiment stationed in Ohrdruf/Thuringia. With both the "Destroyer 45" and "Eastwind II" configurations the German Army had at their disposal the most fire intensive, powerful anti-aircraft ordnance to appear on either side during World War II.

4.6.2.7 Prototype anti-aircraft tank with U-boat conning tower with twin 3 cm Mk 303 cannon

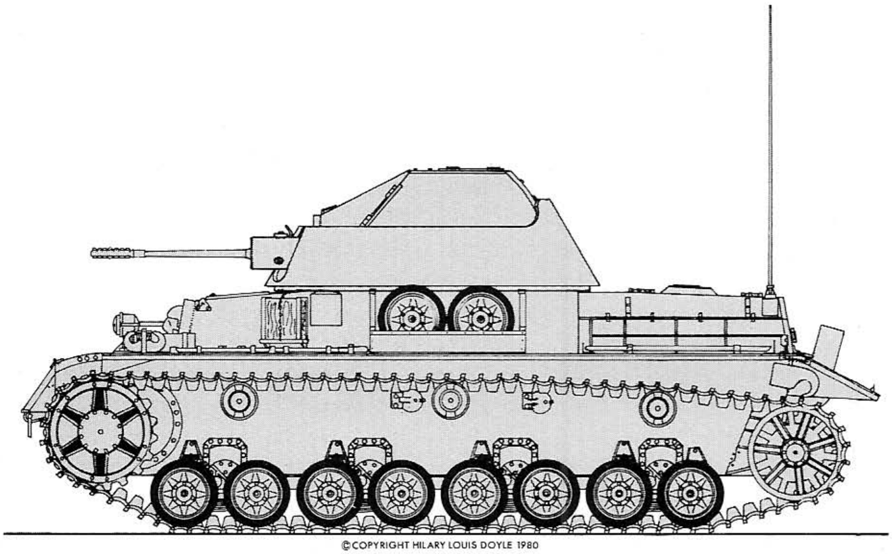
In January 1944, Altmärkische Kettenwerk GmbH. (Alkett), Berlin carried out a series of trials with a twin, 3 cm – Mk 303 – Flak (Brünner Ordnance Factory), mounted on a U-Boat conning tower. Upon their being informed of these trials, the Army General Staff issued an order on April 20th, 1944 that the first series produced batches of these weapons should be allocated for arming submarines. For installation on a Mk IV tank chassis, this armored turret (60 mm armor) should initially be fitted with a twin, 2 cm Flak, which would be replaced later by the new twin, 3 cm Flak. However, series production of the 3 cm Mk 303 machine cannon never started, in spite of the urgent request in the middle of 1944 by the Army General Staff that all development work be quickly concluded.

4.6.2.8 Prototype "Ball lightning" (Kugelblitz) anti-aircraft tank on Mk IV tank chassis with twin 3 cm Flak 103/38 cannon

On November 4th, 1944 the Army General Staff was for the first time informed about the existence of the "Ball Lightning" Anti-Aircraft Tank development project when they were shown photographs of the prototype. This system was unique in its being the first totally enclosed steel turret to have been mounted on the Mk IV tank chassis. Turret configuration was based upon designs originally drawn up by 1st Ltn., Dipl.-Ing. Josef von Glatter-Götz of Inspectorate 6, Automotive Section, Armored Forces Inspectorate, Army General Staff Office. Dept. Wa Prüf 6 of the Army Ordnance Office had commissioned Daimler-Benz of Berlin-Marienfelde to undertake the necessary construction work. "Ball Lightning" received as armament, two, type 103, 3 cm caliber machine-cannon manufactured by Rheinmetall-Borsig. These same weapons had already been installed in ground attack aircraft as anti-tank weapons. Due to their high rate-of-fire they were suited for further deployment as anti-aircraft ordnance. Originally these cannon had been developed by the



Prototype "East Wind II" Anti-Aircraft Tank, armed with twin, 3.7 cm Flak 44 weapons

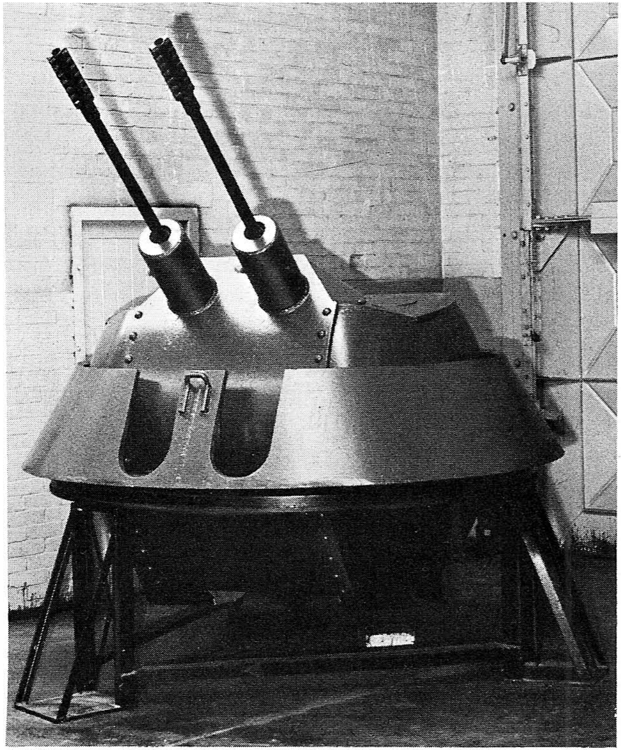


Prototype "Ball Lightning" Anti-Aircraft Tank mounting twin, 3 cm Flak 103/38 cannon

Reich Air Ministries, Master General of Ordnance expecially for installation in the ME 262 aircraft. Operation was electro-pneumatic (electrically fired/compressed-air operated), its ammunitions maximum ceiling being three thousand five hundred meters. The smoke discharged by the ammunition when fired was comparable to that produced by both the 3 cm Mk 303 (Brünn) and 3.7 cm Flak 43 weapons.

The compact dimensions of the weapons together with the belted ammunition proved to be ideally suited for installation in the closed turret. Conversion of the electro-pneumatic firing and loading mechanism to that of a mechanical system was undertaken by "Ostbau-Sagan" in September 1944. Rheinmetall Borsing AG's Guben factory received a contract for the pre-production planning of the

The enclosed, semi-spherical turret housing of the "Ball Lightning" Anti-Aircraft Tank with twin, 3 cm Flak 103/38 cannon installed. The entry hatch for the turret crew is open. This turret can still be seen today in England.



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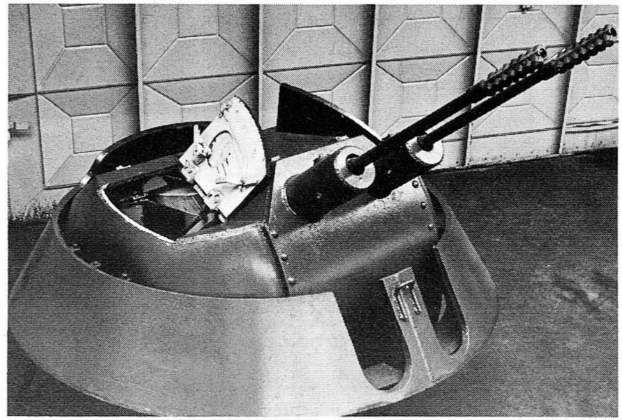
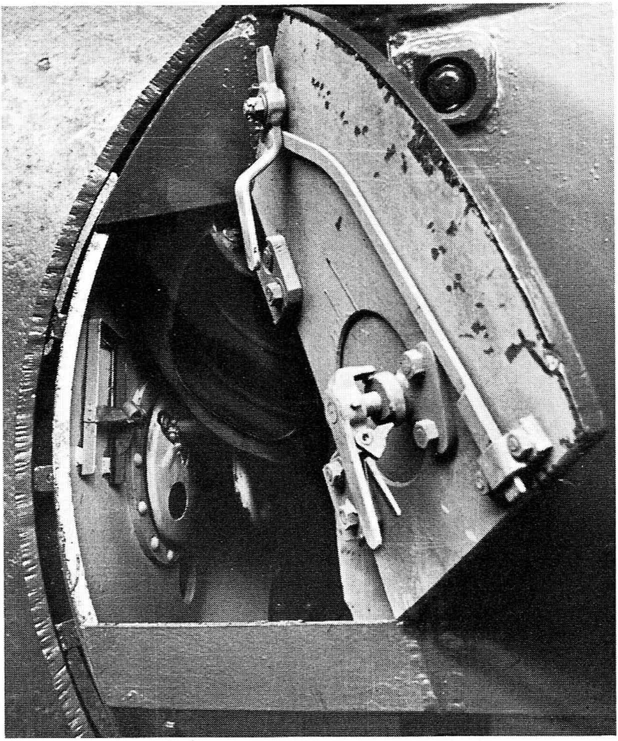
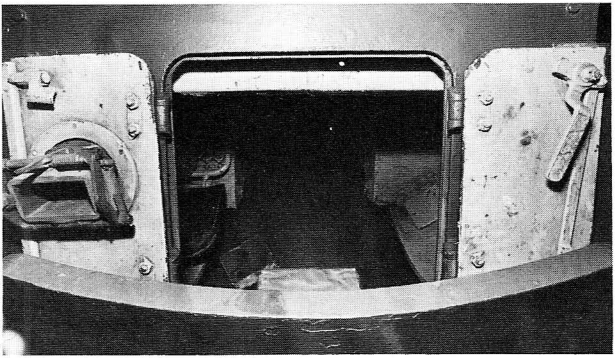
The enclosed, semi-spherical turret housing of the "Ball Lightning" Anti-Aircraft Tank with twin, 3 cm Flak 103/38 cannon installed. The entry hatch for the turret crew is open. This turret can still be seen today in England.

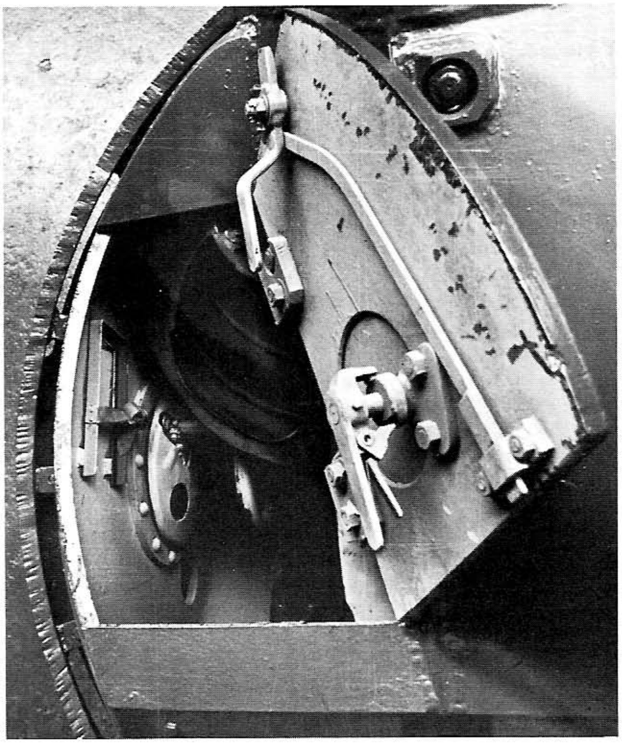




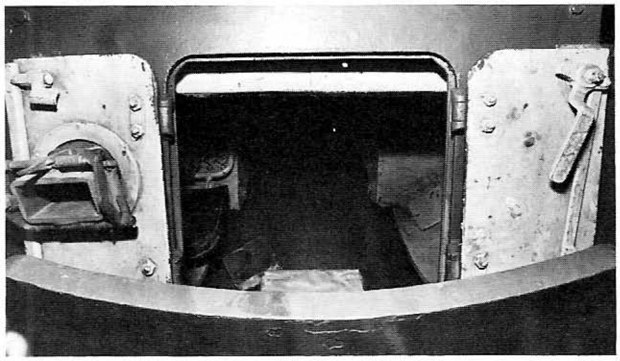
The various access hatches in the "Ball Lightning" Anti-Aircraft Tank turret.



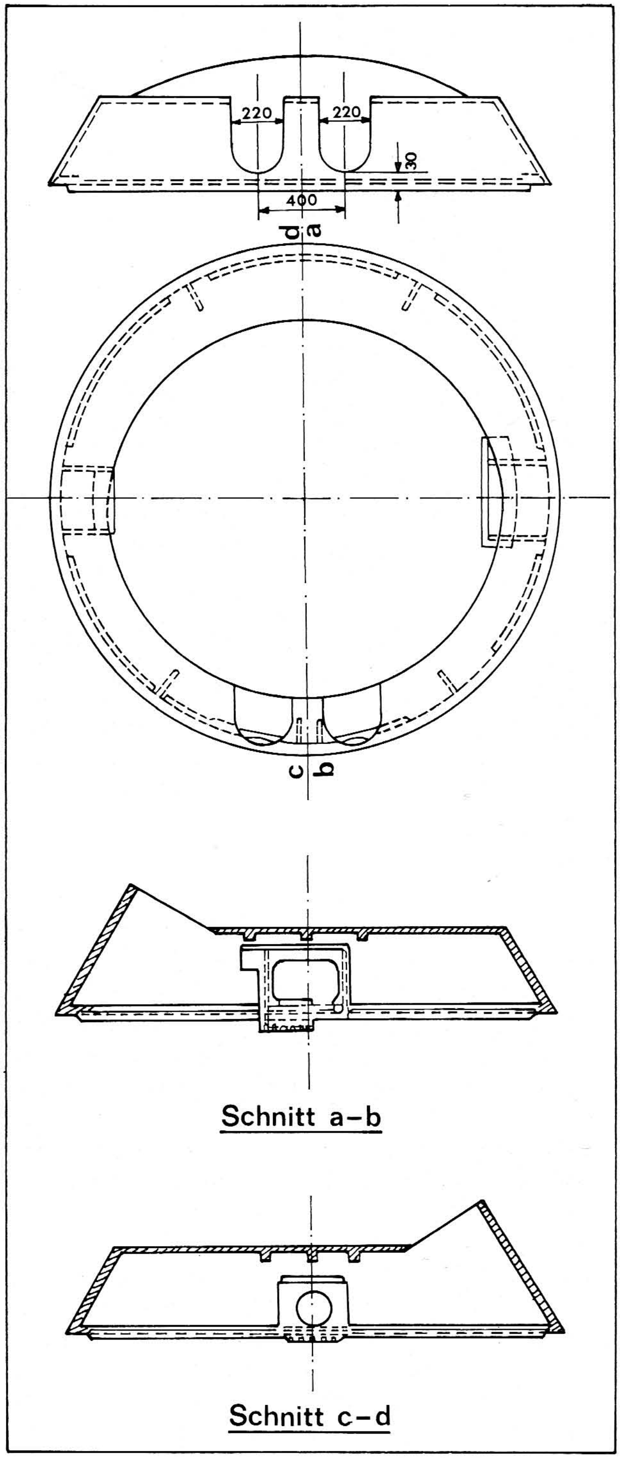
weapons and also undertook series planning studies for manufacturing the cannon as an anti-aircraft weapon. During which time they developed a new extended "Flak" barrel, 2.3 meters long (earlier barrel length was 1.61 meters), in order to increase the weapons performance. Rate-of-fire was between four hundred and twenty-five and five hundred rounds per minute, with a range of fire of five thousand seven hundred meters. The new ammunitions when hitting a target was considerably more effective than the earlier 2 cm caliber weapons. In order to acquire first-hand experience with belted rounds fed from box-type magazines containing thirty to forty rounds of ammunition, "Ostbau-Sagan" mounted the weapon on a modified, 2 cm "Flak"Field Gun Carriage. This trial unit revceived the name "Fighter Bomber Scarer" (Jaboschreck), later officially designated the 3 cm Flak 103/38. As its name "Fighter Bomber Scarer" implied, the advantages of this new 3 cm weapon when compared to its 2 cm caliber predecessor were obvious. Now for the first time, enemy fighter bombers could be successfully engaged. Herewith the German Army received their first piece of belt-fed ordnance, such belt-feeds were a considerable improvement to the magazines and ammunition racks generally in use at this time. It was also a very important pre-requisite for installation in armored vehicles. These advantages were convincingly demonstrated on October 16th, 1944 at firing trials on the Kummersdorf Ranges held under the auspices of the Inspector General of Armored Forces (Insp. 6). Major objectives of these trials was to display the various new anti-aircraft tanks and guns which had been developed, to the Reich Air Ministry, Army General Staff and German industrial observers.

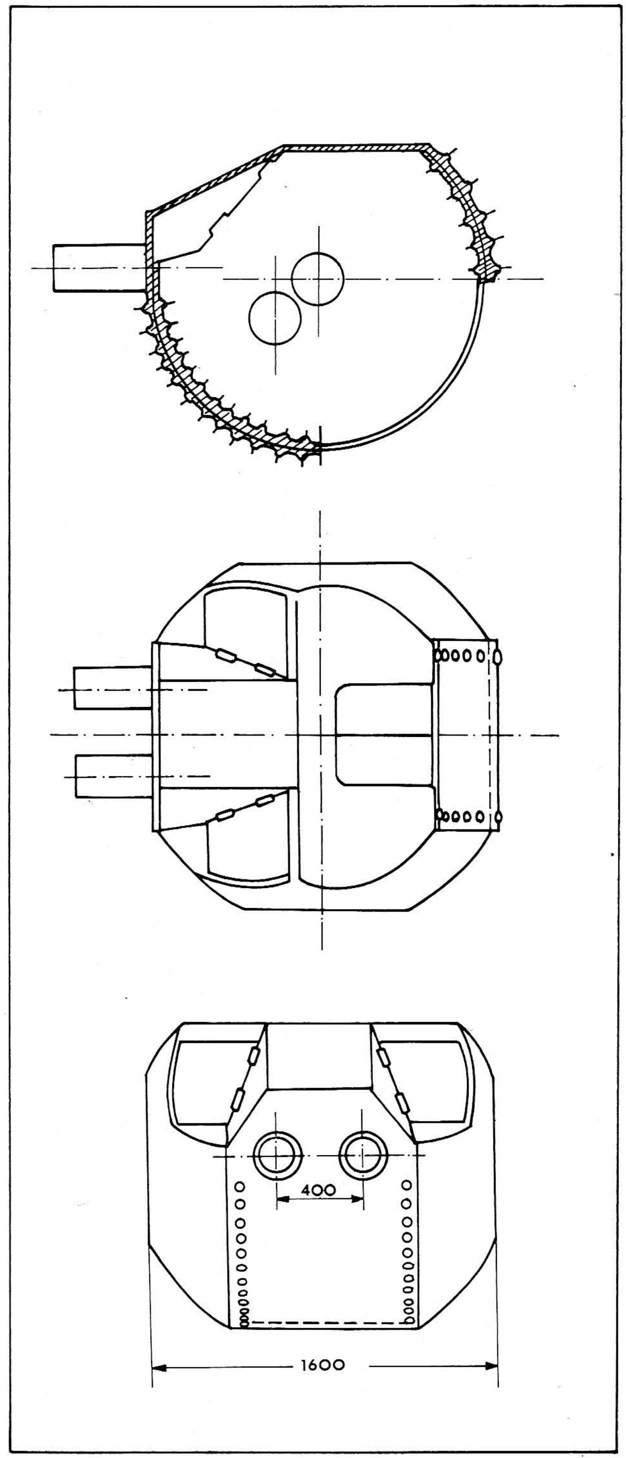


The various access hatches in the "Ball Lightning" Anti-Aircraft Tank turret.

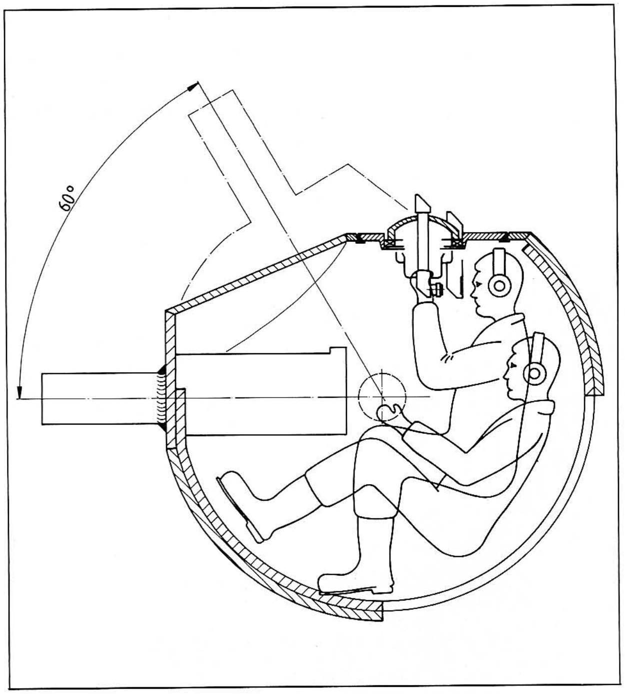


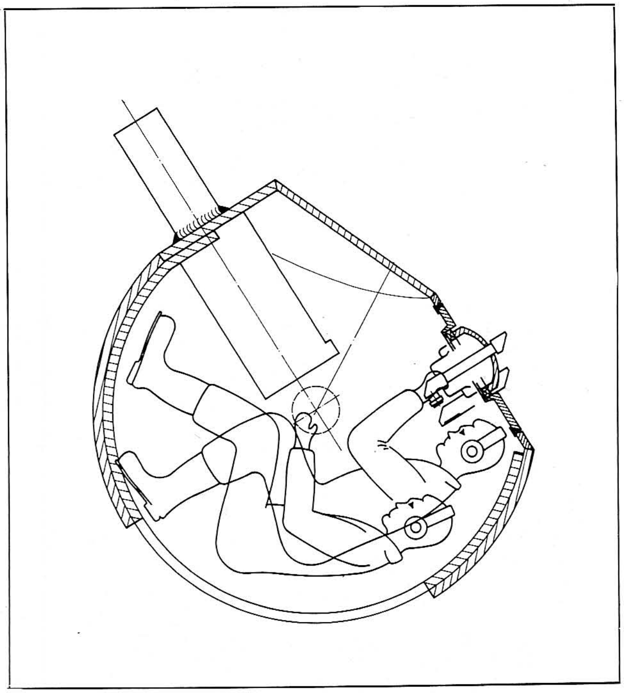
"Ball Lightning's" turret consisted of an inverted half-spherical housing (calotte), containing two symmetrically displaced parallel mounted, 3 cm-caliber, Mk 103/38 cannon and three-man crew, seated in semi-reclined positions. The calotte itself was suspended via gimbals in a truncated conical protective housing. A pneumatic compensator was used to counter-balance the calotte when rotation through its elevatory sweep. Assembled both calotte and conical protective housing were mounted on the 1,900 mm diameter. "Tiger" tank turret race. Overall height of the "Ball-Lightning" was 2,300 mm, turret height being a mere 600 mm. The calotte could be rotated in elevation from minus seven to plus eighy degrees, turret slewing speed was sixty degrees per second. As the mechanical drives proved to be too slow, the German Aircraft Research Establishment, in Berlin-Adlershof developed a new "joy-stick" controlled, hydraulically driven, turret drive unit.





Left the protective mantle, right the spherical turret housing of the “Ball Lightning” Anti-Aircraft Tank.



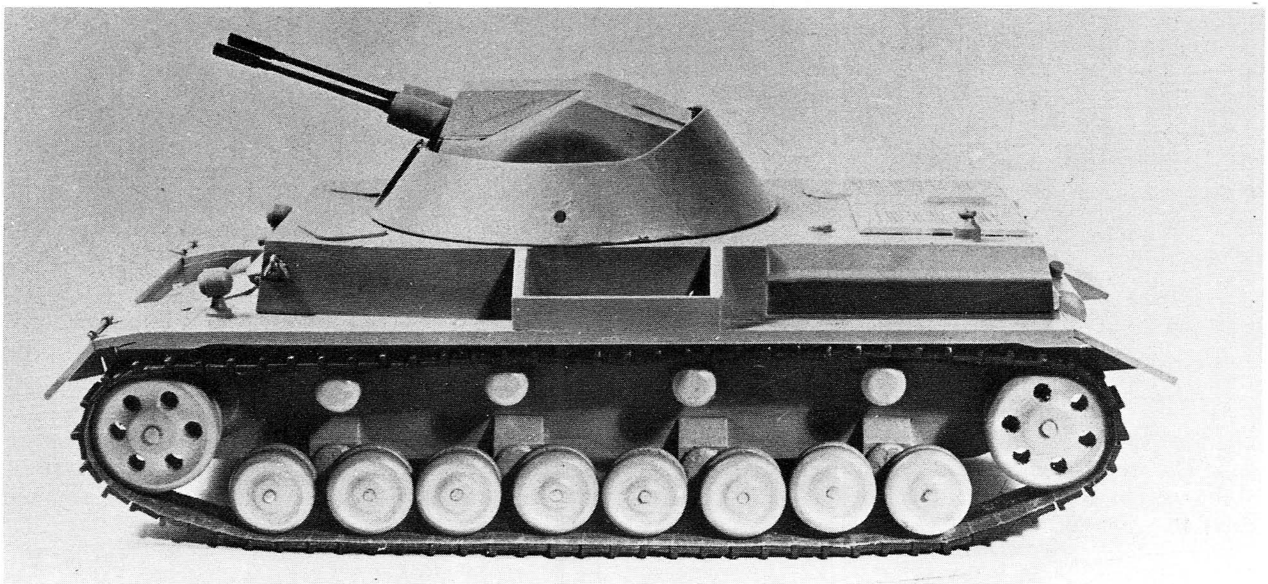


The final turret configuration for the "Ball Lightning" Flak Tank, showing the commanders small observation cupola. The crew moved in accord with the elevational movements of the turret. To the left, the turret at 0° elevation, to the right at +60°. Due to the crew movements with the turret the turret dimensions could be held to an absolute minimum.

An armor protected, stereoscopic sight was installed, the commander passing acquired targets to the gunner for engagement via a tracking device especially for that purpose. In the final turret configuration it had been intended to provide the commander with a small cupola. Surveillance took place via either periscope or elbowed telescope, both of which were fitted, the latter also serving simultaneously as a stereoscopic range finder.

Each of the cannon housings within the turret were fitted with extractor fans for evacuating powder smoke and fumes when firing. On-board ammunition totalled twelve hundred rounds, discharged cartridge cases and belt-clips dropped into canvas bags located under the weapon breeches. The Army regulation publication, No. 761 of 1944, announced the planned introduction of the "Ball Lightning" into service. Officially the vehicle received the designation "Light Anti-Aircraft Tank, Mk IV, 3 cm "Ball Lightning". It was planned that this vehicle would from January 1945 onwards, replace the light "Eastwind" AA-tanks armed with the 3.7 cm – Flak 43 on the Mk IV tank chassis. From February 1945, series production of thirty vehicles per month was forecast, bomb damage and shortages of the necessary materials however prevented these plans from becoming a reality. Besides which the impact of "Emergency Armament Production Program" announced at this time brought all further efforts to a stand-still. Despite all these set-backs occurring Deutsche-Eisenwerke AG, still managed to complete five prototype vehicles at their Steel Industry Works in Duisburg. These were delivered to the troops at the beginning of 1945. Whereafter they were assigned to the newly established, Armored Flak Replenishment and Training Regiment, stationed at the Troop Training Grounds in Ohrdruf/Thuringia.

Each company of this regiment was made up of three batteries having four "Whirlwinds", "Ball Lightnings", "Eastwinds" and "Furniture Van" anti-aircraft tanks. In a trials battery composed of "Eastwind II's", "Destroyer 45's" and "Ball Lightning II, 38 D's" the combined, theoretical operational deployment was investigated. 1944 saw each headquarter's squadron of each armored regiment having eight, 3.7 cm "Furniture Van" AA-Tanks assigned to them for aerial defense. The headquarters troop of each armored squadron each receiving three, quadruple, 2 cm "Whirlwind" AA-Tanks for the same purpose.



Wooden mock up of the "Ball Lightning" Anti-Aircraft Tank. Five prototypes of this vehicle had been produced by the time the war ended. This was the first anti-aircraft tank to have a totally enclosed turret.

4.6.2.9 Synopsis of Anti-Aircraft Tank Production During the Years 1944 to 1945

From the few documents remaining for the years 1944 to 1945, it has been possible to ascertain the production targets established for self-propelled gun-carriages and anti-aircraft tanks:

Table 3a: Production Target Figures

	1944 Aug.	Sept.	Oct.	Nov.	Dec.	1945 Jan.	Feb.	Mar.
Self-propelled 3.7 cm Anti-Aircraft Cannon	30	30	25	run completed				
"Whirlwind"	15	18	20	15	15	run completed		
"Eastwind"	—	—	—	30	30	10	run completed	
"Ball Lightning"	—	—	2	3	–	20	30	30

Consequential to series production of the "Eastwind" being delayed, the Army Ordnance Office placed a contract with Deutsche-Eisenwerke, Duisburg, in December 1944 for a further twenty-five, self-propelled (3.7 cm), "Furniture Vans". These vehicles were never delivered, thereby the following delivery quantities resulted:

Table 3b: Quantities Actually Produced

	Self-Propelled 3.7 cm Anti-Aircraft Cannon 43 "Furniture Van"	Anti-Aircraft Tank 2 cm Quadruple Cannon "Whirlwind"	Anti-Aircraft Tank 3.7 cm Cannon "Eastwind"	Anti-Aircraft Tank Prototypes
1944				
March	20	–	–	–
April	20	–	–	–
May	15	–	–	Whirlwind
June	34	–	–	–
July	31	–	–	Eastwind I
August	30	22	–	–
September	24	30	–	–
October	14	10	–	–
November	10	30	–	–
December	7	8	15	Destroyer 45 (2)
1945				
January	–	3	13	Eastwind II
February	–	2	7	Ball-Lightning (5)
March	–	–	8	–
Totals	205	105	43	10

Table 4
The Armored Training Division (Panzer Lehr-Division), well-known as one of the elite of the armored divisions, was officially to have the following strengths of Anti-Aircraft Tanks. Whereas in fact only the following Anti-Aircraft Tank strenghts were realised.

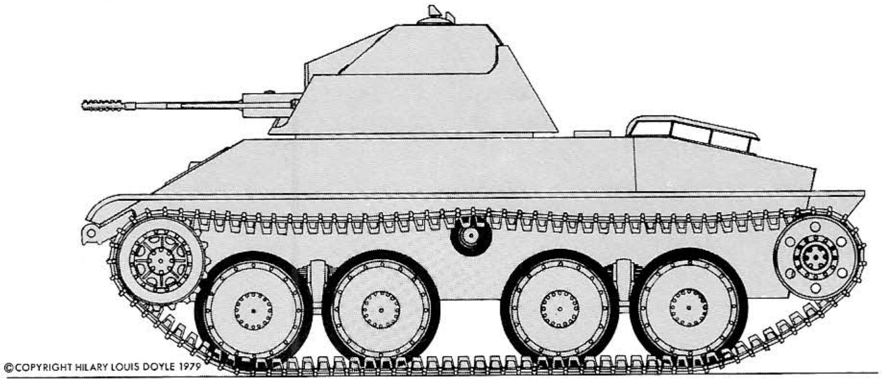
UNIT	Listed Strength 44th Armored Division	Effective Strength June 1944	Effective Strength December 1944
Divi'sn. Excort Coy.	1 Lgt. Self-Prop- "Flak" Troop	4–2cm – Single Barrel "Flak" (Sd. Kfz 10/4)	4–2 cm – Single Barrel "Flak" (Sd. Kfz 10/4)
Armd. Lehr Regt. HQ 1 and 1st Battalion	1 Armored "Flak" Troop	12–2 cm – Type 38 "Flak" Tanks (Sd. Kfz 140) 2–2 cm – Quadruple "Whirlwind" Flak Tanks	6–3.7 cm – "Eastwind" Flak Tanks 2–2 cm – Quadruple "Whirlwind" Flak Tanks
Anti-Tank Battalion	1 Armored "Flak" Troop	2–2 cm – Quadruple "Whirlwind" Flak Tanks	2–2 cm – Quadruple "Whirlwind" Flak Tanks
Armored Infantry			
I/901	27–2 cm – Mounted "Flak" (AFV)	–	27–2 cm – "Flak" Cannon
II/902	27–2 cm – Mounted "Flak" (AFV)	–	6–2 cm Mountain "Flak"
II/901	3 – Troops – Light "Flak" (SP)	8–2 cm – Quadruple "Flak"	–
I/902	27–2 cm – Mounted "Flak" (AFV)	–	6–2 cm Mountain "Flak"
II/902	27–2 cm – Mounted "Flak" (AFV)	–	6–2 cm Mountain "Flak"
Armored Recce Troop	7–2 cm – Mounted "Flak" (AFV)	–	3–2 cm "Flak" Cannon
Armored Engn. Troop	3–2 cm – Mounted "Flak" (AFV)	–	3–2 cm "Flak" Cannon
Armored Artillery Regt.			
Ist Squad.	1 – Troop – Light "Flak"	3–2 cm – Mountain "Flak"	3–2 cm Mountain Flak
IInd Squad.	1 – Troop – Light "Flak"	3–2 cm – Mountain "Flak"	3–2 cm Mountain Flak
IIIrd Squad.	1 – Troop – Light "Flak"	3–2 cm – Mountain "Flak"	3–2 cm Mountain Flak

This was the equipment status actually held by the division in June 1944 while countering the Allied Landing in Normandy and latterly in mid-December 1944, during the Campaign in the Ardennes.
The Army's 311th Anti-Aircraft Battalion of the Armored Training Division did in fact have several "Whirlwind" and "Eastwind" Tanks in 1944/45.

4.6.2.10 Prototype "Ball Lightning II" (Kugelblitz II) anti-aircraft tank on 38 D tank destroyer chassis with two 3 cm Mk 103/38 and two 2 cm 151/20 guns

November 1944, saw the Army Ordnance Office/ Wa Prüf 6 authorising development of a new "Ball Lightning" turret. In the first instance it was planned to fit this turret with twin, rapid firing, 3 cm-type 103 Anti-Aircraft Guns. This new turret was to be mounted on the chassis of the 38 D Tank Destroyer Vehicle. The new system received the equipment No. 638/15 and Daimler-Benz built a wooden model of the turret in Marienfelde. Besides the two 3 cm – Mk 103/38 weapons, two 2 cm 151/20 cannon were installed. All four weapons being fitted within the spherical turret which in its turn was mounted on the turret race of the Mk IV tank. Initially two temporary mechanical drives were used for "slewing" the turret and elevating the weapons. These were to be replaced later by hydraulically powered, joy-stick controlled drive units. Weapon elevation speed was forty-five degrees per second, turret "slewing" speed twenty-two degrees per second. Joy-stick movement was exponential i.e.: the lower the laying speed, the longer the joy-stick movement, and viece-versa. Joy-stick controls like this were directly taken over from those supplied to the aircraft industry and used without any major modifications. The standard, suspended ring-sights used in the earlier roofless turrets were no longer suitable for installation. In special stereoscope with 8 mm apertures in the turret armor, protruding 200 mm beyond the outer facing was used. Field-of-view was sixty degrees. Aiming at a target was facilitated by an aiming spot becoming visible in the centre of the sighting reticle, indicating interception point of

"Ball Lightning II" Anti-Aircraft Tank armed with both twin, 3 cm Flak 103/38 and twin, 2 cm Flak 151/20 cannon



shell and target. Furthermore, a series of thin black ranging lines which all centred on the aiming spot were incorporated within the sight as an additional aid to the gunner, these lines were broken at every three or five hundred meters scale marks as a ranging aid. When aiming the gunner had to select the most suitable of these lines running parallel to the aircrafts axis and then continue tracking the target along this same selected line. Should the commander give a range of one thousand meters, the targets nose would have to be at the thousand meter ranging point of whichever line had been selected.

At shoulder height, the commander was equipped with a small cupola, which could be rotated and elevated manually by means of two hand-grips. After a target had been detected using the surveillance periscope, further observation continued by means of a somewhat lower sited optical unit with a magnification factor of 1:6. This optic together with two pairs of vision blocks (one pair per side) protruded throught the cupola roof. Sterescopic type range finding being established by these means. Coupled to the search joystick of the commander was a target indicator positioned directly facing the gunner, rendering all further verbal communication between them superfluous. The gunner using his joy stick only needed to position and retain the tracking indicator at its zero setting to obtain the target in his sights.

Centrally displaced, close to one another within the turret were two 3 cm caliber, machine cannon complete with ammunition guide chutes. Sited outboard of each of these weapons were the two 2 cm caliber MG 151/20 machine cannon*. By means of two firing pedals the gunner was able to fire these weapons in any combination desired.

Table 5: "Ball Lightning" (Kugelblitz) Anti-Aircraft Tank Prototype Data

	Ball Lightning on Mk IV Tank Chassis	Ball Lightning on Tank destroyer 38-D Chassis
Crew, Turret	3	2
Crew, Hull	2	2
Turret Traverse Speed	10°/s	45°/s
Elevating Speed (Weapons)	6.7°/s	22°/s
Field-of-Elevation	–5° to +70°	–5° to +70°
Firing Cadence (rounds per minute)		
30 mm cannon	650	650
20 mm cannon	–	720
Ready Ammunition		
30 mm Cannon	200	250
20 mm Cannon	–	300
Total Ammunition Supply		
30 mm Cannon	*1,200*	*1,200*
20 mm Cannon	–	*1,000*

Suspended below the cupola at the same level as the turret ring were four semi-circular, basin type receptacles, which were used for storing the belted – "ready ammunition" arranged in a zig-zag fashion. These belts were fed to the gun breeches

* Two 2 cm barrels for ranging fire
Two 3 cm barrels for effective fire
(according to the concept by Dipl.-Ing. Josef von Glatter-Götz)

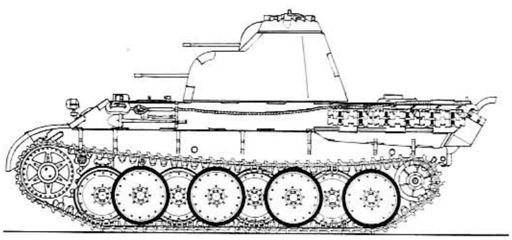
via sheet metal guides, with telescopic links, absorbing the distance between the breeches and guides caused by elevational movement of the weapons.

As the turret, complete with its crew automatically followed all the traversing and elevational movements of the weapons the positions of the weapons within the turret remained fixed. The only exception being the recoil movement of the breeches. Use of this form of turret design meant that the dimensions of the turret could be kept to an absolute minimum.
The turret crew were fully integrated with all the operations taking place within their turret. One major disadvantage of this system was the extremely cramped conditions suffered by the crew, and the limitations made upon the amount of ammunition which could be carried.

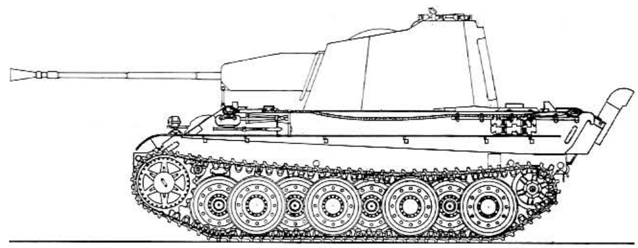
4.7 Anti-Aircraft Tank Studies Based Upon the Panther Tank Chassis

After the Panther Tank had become the new standard tank of the German Armored Divisions,

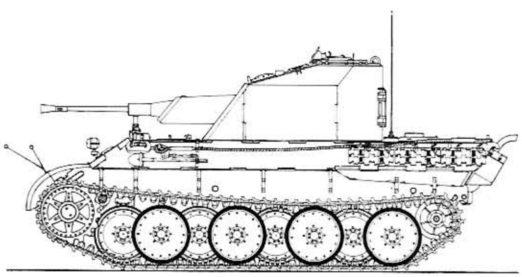
Comparison of Anti-Aircraft Tanks mounted on the Panther Tank Chassis



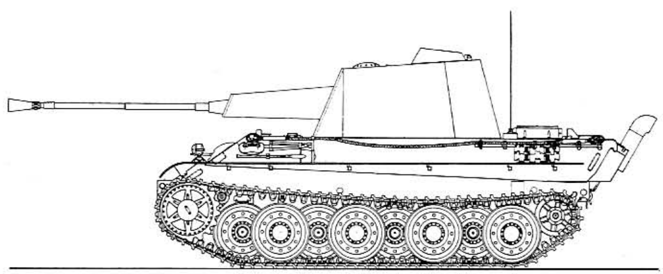
Anti-Aircraft Tank Design with quadruple, 2 cm MG 151/20 cannon



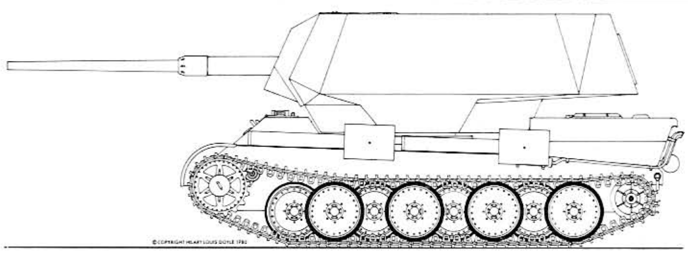
Krupp design Anti-Aircraft Tank with twin, 5.5 cm Flak weapons



Prototype Anti-Aircraft Tank with twin, 3.7 cm Flak 44 cannon

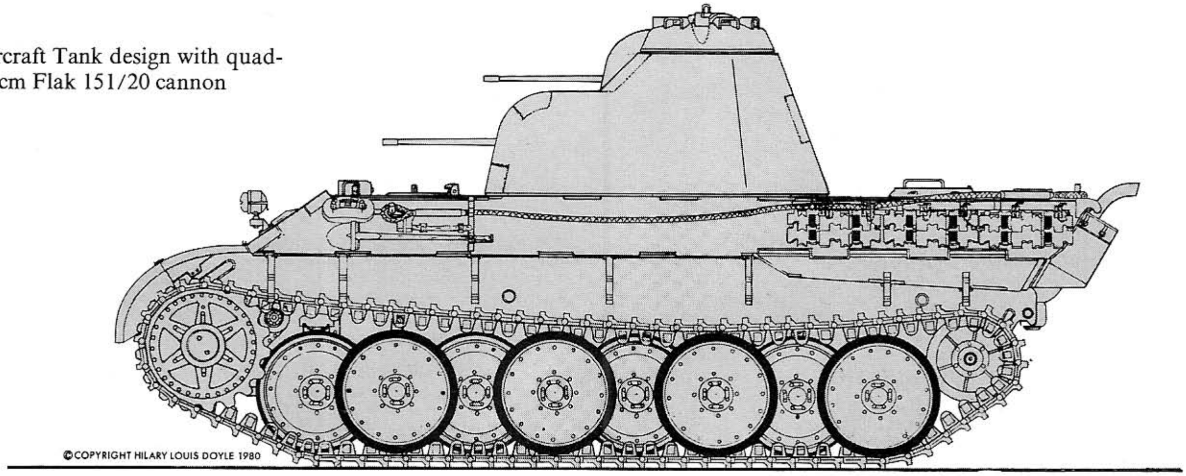


Rheinmetall-Borsig design Anti-Aircraft Tank with twin 5.5 cm Flak weapons



Anti-Aircraft Tank Design with 8.8 cm Flak 41 as armament

Anti-Aircraft Tank design with quadruple, 2 cm Flak 151/20 cannon

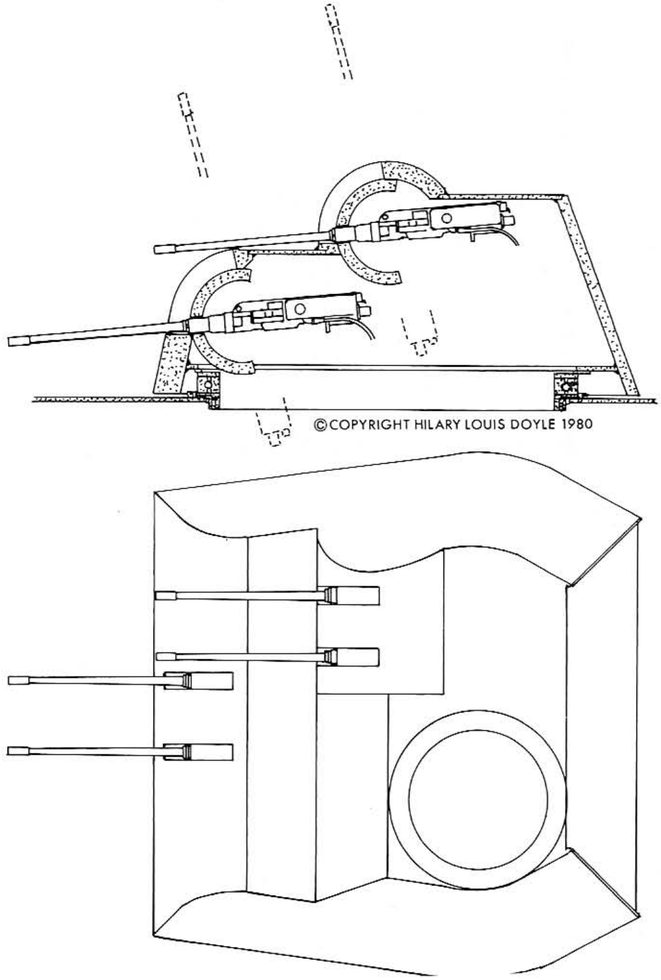


a series of studies were carried out to investigate a variety of other applications of the chassis. Included amongst these were possible use for either self-propelled anti-aircraft gun carriages and tanks.

As early as September of 1942, the Luftwaffe's Ordnance Master General/Flak had discussed with Krupp an improved research air defense vehicle. The maximum utilisation and integration of Panther tank components was ordered. On November 4th, 1942, engineering drawings for such an anti-aircraft (Equipment 42) tank were discussed, indicating that the following Panther components were defined, for use, such as the running-gear, track tensioning units, drive sprockets, final drives, hand/foot operating levers and pedals, ZF-Type AK 7–200 gearbox and Maybach HL 230 engine. However due to the extremely precarious war situation, neither the Commanding General of Armored Forces or Inspectorate 6 could spare either a Tiger or Panther chassis. All available chassis were being used for tank production. In the Commanding General of Armored Forces opinion, all supporting arms such as Anti-Aircraft and Field Artillery should be given all the Mk III and Mk IV tank chassis which were surplus to his own troops requirements. These chassis could then be converted as required, it was assumed that all such chassis were suited for the proposed conversions. The Commanding General of Armored Forces had already pointed out early in 1943, that he saw no possibility whatsoever of Panther tank chassis being made available for anti-aircraft tank conversions. The decisive blow to all proposed study and development plans fell on January 23rd, 1945. It was on this day, that recognising the ever decreasing productive capabilities of German industry, Reichs Minister Speer announced his "Emergency Armaments Production Program", replacing the earlier preceding "Victory Program" of Summer 1944, which had also undergone various amendments since its conception. From this moment on the continuation of minor developments and studies become impossible.

4.7.1 Anti-Aircraft Tank Armed with Quadruple, 2 cm MG 151/20 Cannon

On May 21st, 1943, Rheinmetall-Borsig submitted their design lay-out for a new tank turret mounting quadruple, MG 151/20 automatic machine cannon as armament. These 2 cm caliber weapons were mounted in two pairs one above the other, they were displaced in the vertical plane in order to provide a wider spread of fire. Weapon elevation ranged from –7° to +75°. The thickness of the totally enclosed turret's armor had been maintained identical to that of the standard tank turret. This configuration never reached any advanced stage of development, no doubt influenced by the Commanding General of Armored Forces never having liked it.



Scale drawings and details of the weapon mounts were made from original drawings viewed in the Military Archives in Freiburg, West Germany.

4.7.2 "Coelian" Anti-Aircraft Tank Armed with Twin, 3.7 cm "Flak" Cannon

At the beginning of 1943, Oberleutnant Dipl.-Ing. von Glatter-Götz, who had been made responsible for all anti-aircraft tank developments by Inspectorate 6, contacted Rheinmetall-Borsig. After which time with the approval of the Army Ordnance Office/Wa Prüf 6, a twin, 3.7 cm "Flak" configuration was developed, Equipment No. 554. During the period the new ordnance underwent trials, the constructional development of the turret was completed in Autumn of 1943. The organ manufacturing company Rieger Brothers, of Jägerndorf, built a wooden model of this turret which Daimler-Benz, Berlin-Marienfelde mounted on a Panther tank chassis. The first Panther Anit-Aircraft tank being demonstrated on December 7th, 1943 at Hitlers East Prussian Headquarters in Rastenburg. Although the demonstration proved to be impressive, Director Saur of the Reich Ministry for Armament and War Production, totally rejected these new Rheinmetall weapons in favor of the 3.7 cm "Flak 43" cannon already in service. One major problem which remaines unsolved with these weapons was that when elevated to their 90° maximum, the belted ammunition in the guide chutes was twisted up to 45°. Furthermore, the problems of evacuating used shell cases, powder smoke and fumes had not been resolved. No further prototypes were produced, the concept as it stood, did however receive Oberleutnant von Glatter-Götz's third Christian name "Coelian" as it's name.

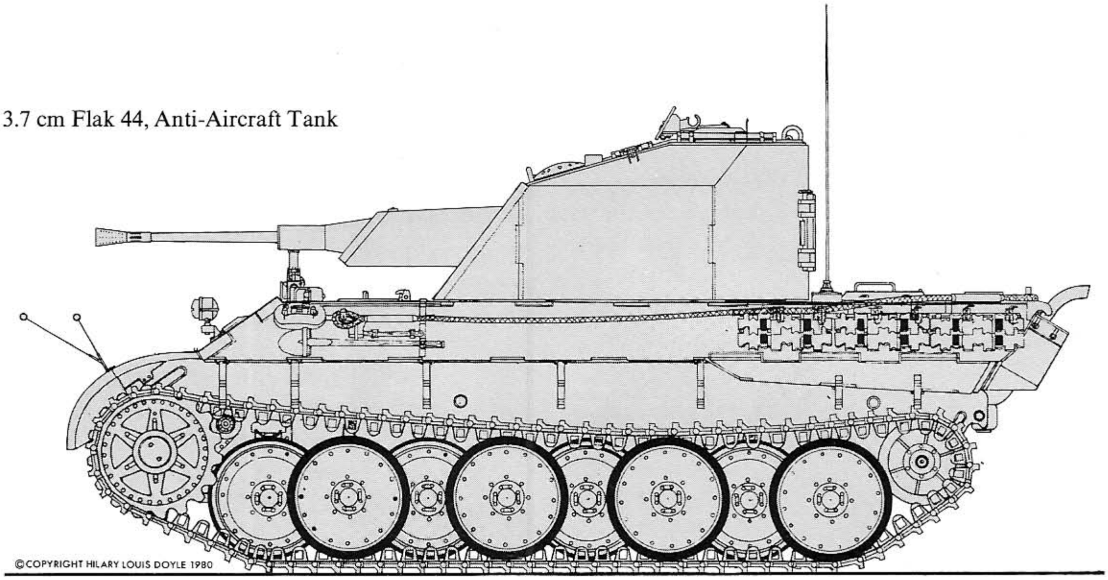
Table 6: "Coelian" Anti-Aircraft Tank

Crew	4–5
Combat Weight	40 tons
Height	2.8 meters
Rate-of-Fire	400 rounds-per-min.
Ammunition Supply	1,500 rounds
Turret Armor: Shield	80 mm
Turret Armor: Front	70 mm
Turret Armor: Sides and Rear	40 mm
Ammunition Feed	Belted
Field-of-Elevation	–5° to +90°

4.7.3 Anti-Aircraft Tank Armed with Twin, 3.7 cm, "Flak 44" Cannon

In 1944, Daimler-Benz and Krupp proposed a joint anti-aircraft tank configuration incorporating twin, 3.7 cm Flak 44 cannon produced by Gustloff Works, Suhl (formerly Simson). The production of these weapons having been facilitated by "Ostbau-Sagan". A turret drawing dated March 28th, 1944 shows a turret, the front of which is angled at forty-degrees and 60 mm thick. This turret being traversed by a hydraulically powered drive taken off the main engine. It had been planned to complete a prototype system by mid-1944, beset by

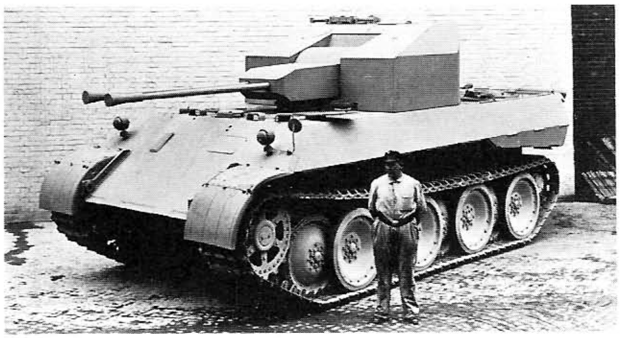
Prototype, twin, 3.7 cm Flak 44, Anti-Aircraft Tank

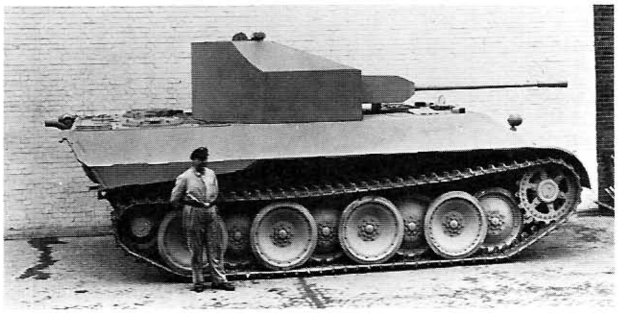


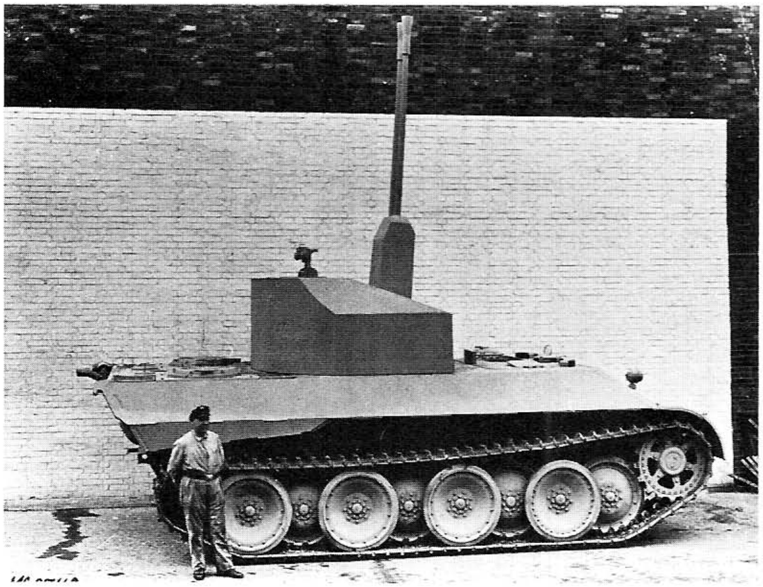
design problems all of which needed solving, this configuration was still at the design stage when the war ended. The installation of a telescopic range finder within this turret had been suggested. Krupp-Gruson when reporting the development status of this anti-aircraft tank turret on January 27th, 1944 commented "In order to resolve mounting of a turret armed with twin, 3.7 cm cannon on the Panther chassis, we would recommend that the existing turret designed by Daimler-Benz be discontinued forthwith. We ourselves would undertake the design of the special turret "necessary". However the Army Ordnance Office/Wa Prüf 6 had serious misgivings that any turret design would prove satisfactory due to the following problems not having been resolved:

1. Evacuation of the gun powder smoke and fumes from the interior of the turret.

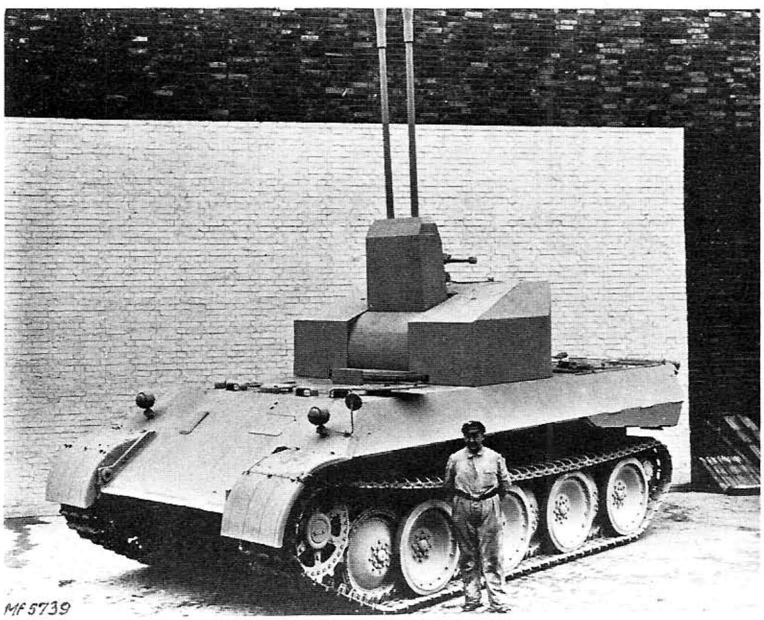
Wooden model of the twin, 3.7 cm Flak turret mounted on a Panther tank chassis. This model was built by Rieger Brothers, organ builders in Jägersdorf. The photographs show the Panther vehicle with it's wooden turret in the "march" position.







Study model of the Panther Anti-Aircraft Tank, mounting twin 3.7 cm Flak weapons, guns at the maximum elevation.



2. Effectively sealing-off the spurious tongues of flame exuding from the cannon breech when firing.
3. Target acquisition.

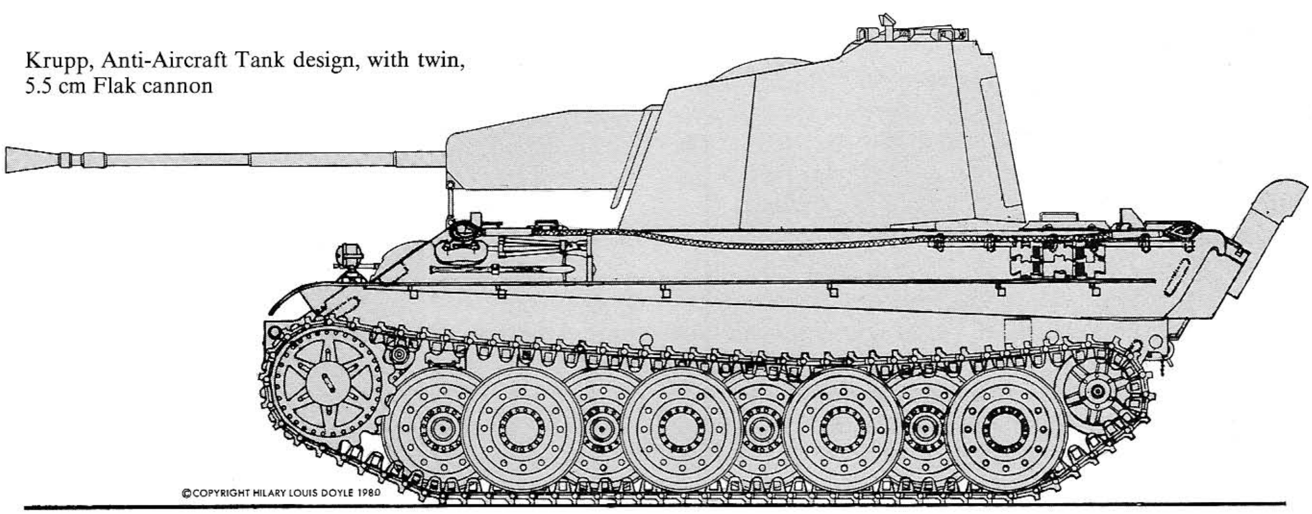
However as a possible alternative solution, the installation of a single 3 cm cannon was already planned in case the twin, 3.7 cm weapons were not available by the Autumn of 1944. A prototype by the end of 1944 could not be expected either. The twin, 3.7 cm "Flak 44" had a firing cadence of 2×500 rounds per minute and a muzzle velocity of one thousand meters per second.
During a meeting between representatives of Wa Prüf 6 and Vereinigte Apparatebau AG, on January 16th, 1945 the latter presented the results of

feasibility studies which they had carried out for further consideration. These studies involved the installation of the twin, 3.7 cm, Flak 44, L/57 in an enclosed armored turret suitable for mounting on the Panther tank chassis. Maximum range of these weapons was six-thousand six-hundred meters, maximum ceiling being four thousand eight-hundred meters. The new turret used the standard Mk IV tanks turret race. After due consideration, Vereinigte Apparatebau AG were informed that their proposal had been rejected by the Inspector General of Armored Forces. The reason given being that the fire-power of the 3.7 cm weapons in relation to the weight of the carrier vehicle was too low. Development was therefore officially ended. In spite of this decision however Vereinigte Apparatebau AG continued pursuing the project at their own initiative and continued with further trials, whereby the twin, 3.7 cm Flak 44 was proposed for both the Mk IV tank and 38 D tank destroyer chassis.

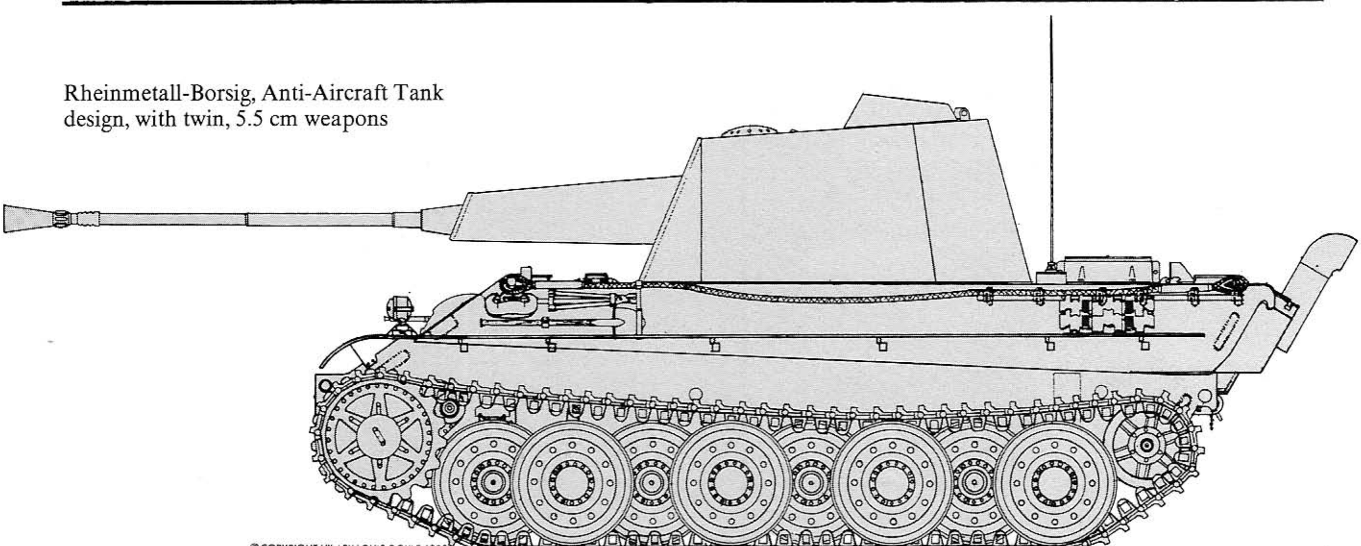
4.7.4 Anti-Aircraft Tank Armed with Twin, 5.5 cm Anti-Aircraft Guns

From the end of January, 1944 trials were carried out with twin, 5.5 cm, Flak 58 cannon, manufactured by Rheinmetall-Borsig. These weapons were

Krupp, Anti-Aircraft Tank design, with twin, 5.5 cm Flak cannon



Rheinmetall-Borsig, Anti-Aircraft Tank design, with twin, 5.5 cm weapons

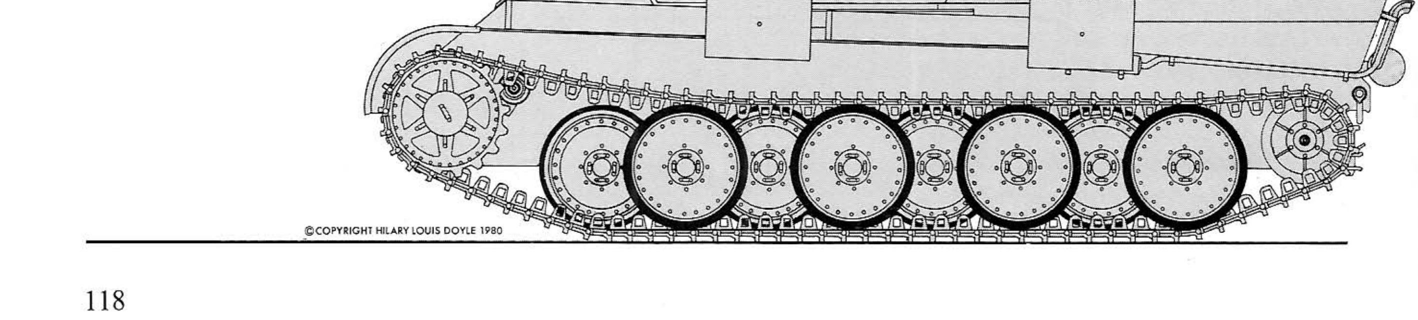


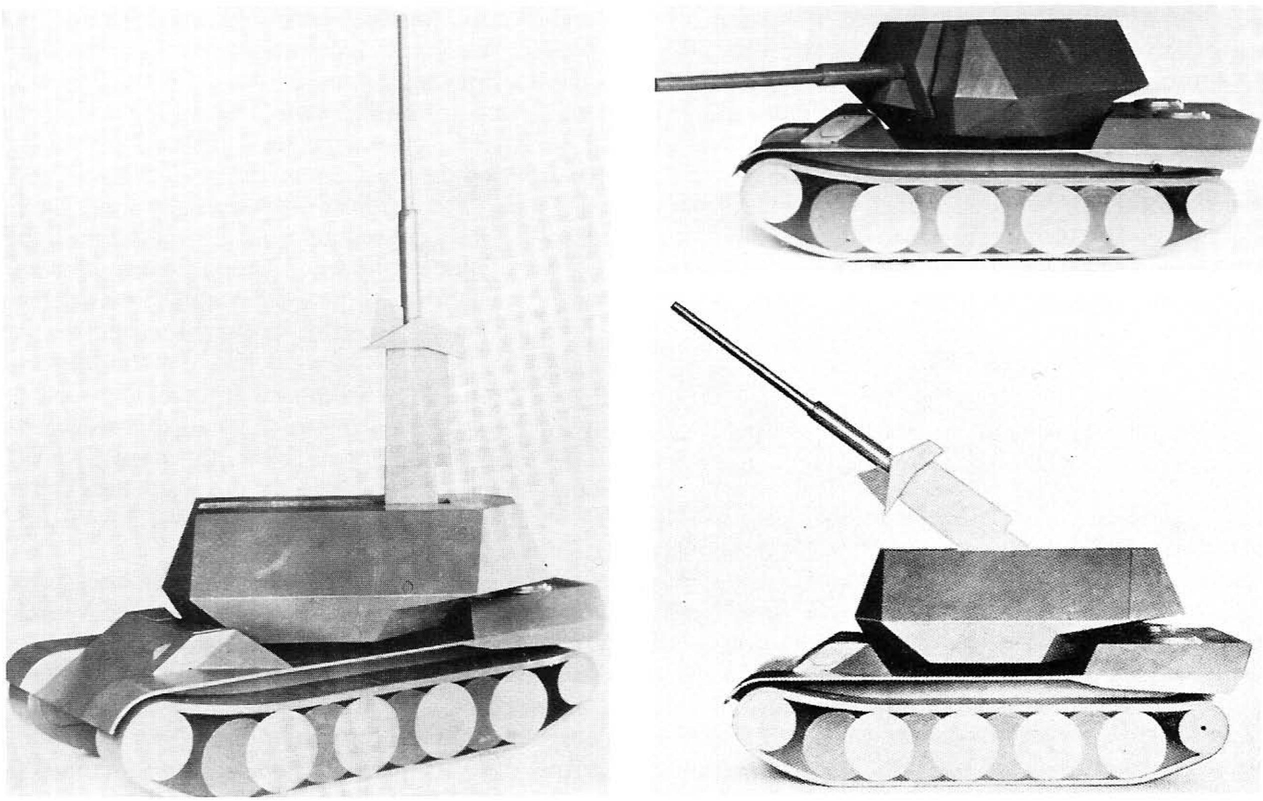
supposed to replace twin, 3.7 cm Flak cannon in an existing turret, after completion this new weapon/turret configuration was mounted on the chassis of a Panther tank. On May 8th, 1944 the Commanding General of Anti-Aircraft Artillery urgently requested that an anti-aircraft tank be developed mounting twin 5.5 cm caliber anti-aircraft ordnance. Hinged, lowerable superstructure sides as previously used with the Mk IV tank chassis were not accepted for this new concept, instead traversable cupola or turret type structure having been specifically requested. Krupp received authorisation to commence developing the turret. After which Rheinmetall-Borsig built three wooden turret models. The recoil energy exerted by the twin, 5.5 cm, 58 Rh DV weapons was four thousand kilos. The cannon barrels were pitched 330 mm apart. Turret traverse, a full 360° and weapon elevations from –5° to +80° were as specified in the requirements. Total weight of the turret was 9060 kilos, a four-man crew was planned. One hundred and four rounds of ammunition were carried on-board. A sighting head was used for aiming. On February 17th, 1945 a wooden mock-up of this 5.5 cm anti-aircraft tank was dismantled at the subsidiary works of Vereinigte Apparatebau AG, in Siedenberg. This was then transported piecemeal to Grimma (Saxony) and reassembled, for presentation to the Army Ordnance Office. In accordance with directives issued by the Army Ordnance Office, Wa Prüf 6, the high pressure, hydraulic turret traverse drive was to be coupled via intermediate pumps, to a hydraulic motor already installed in the existing Panther chassis. Installation of ancillary aggregates was dispensed with due to the lack of available space. As both of the turret drive pumps could not be stowed within the motor compartment because of again insufficient room, they were alternatively sited in the turret basket, adjacent to the oil reservoirs. These drive shaft operated pumps could be switched off when they were not needed. The housing for the turret drive remained unchanged. Since the development of the 5.5 cm anti-aircraft tank was not included in the scope of the "Emergency Armament Production Program", all further development work ceased in January 1945.

4.7.5 Anti-Aircraft Tank, Armed with 8.8 cm "Flak 41" Cannon

At a meeting which took place on June 8th, 1943 development of an anti-aircraft tank armed with an 8.8 cm Flak 41 weapon was decided by Wa Prüf 6. One condition which was imposed however, was that no conversion work on the Panther chassis which was supposed to be available, from September 1943 onwards, was to be carried out until the final design was completed. Production however never started. This self-propelled, Flak gun-carriage, armed with the 8.8 cm weapon and

Anti-Aircraft Tank Concept with the 8.8 cm Flak 41 cannon





Self-propelled Flak gun-carriage, incorporating Panther tank components and armed with the 8.8 cm Flak 41. A proposal for a heavy anti-aircraft tank which was not realised. The photographs are of the wooden scale model of proposed vehicle.

incorporating Panther tank components had first been proposed by the Leipzig Factory of Rheinmetall-Borsig. Technically such a configuration proved itself as being an extremely difficult problem however. The ancillary turret drive aggregates required quite considerable space for their installation. It proved impossible to install the weapon within the turret ring while maintaining both the desired field-of-elevation for the weapon and 360° traversability for the turret. In order to traverse the turret, a traverse drive was required with a power output of 3.5 kW, 380 V at 3,000 r.p.m. Therefore a two-stroke, (type ZW 500) DKW engine was installed. Hydraulic power being supplied via a radial pump. The 1,900 mm high, roofless turret was mounted on a turret ring set 380 mm below the level of the hull deck. Range of the 8.8 cm Flak 41 was 20,000 meters, its firing ceiling 14,700 meters. On January 13th, 1944 the Reich Minister for Armaments and War Production, ordered "Development of the self-propelled, 8.8 cm Flak 41 mounted on a Panther tank derivative chassis to be discontinued forthwith, in favor of more urgent developments". Work was stopped immediately with only one wooden model having been built.

4.8 Anti-Aircraft Tank Developments Undertaken by the Reich Air Ministry

The Luftwaffe's Ordnance Master General/Flak/4 IV, exchanging informative documentation with the Army Ordnance Office, Wa Prüf 6, had been

developing self-propelled, armored, Flak gun-carriages since the Autumn of 1941. As a result of this Krupp-Essen produced prototypes for both light and heavy research vehicles (VFW). The armored walls of these systems superstructures could be lowered. Neither of these vehicles ever reached series production stage however. All further development was cancelled in 1944, their intended tactical roles being assigned to self-propelled, anti-aircraft guns based upon existing battle tank chassis.

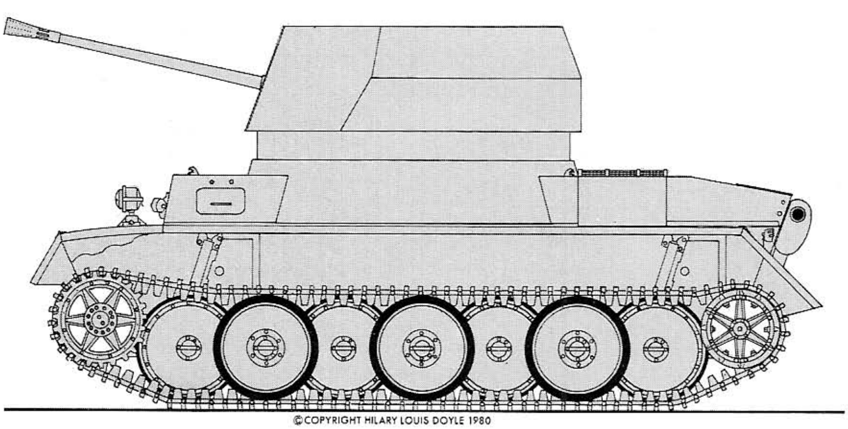
4.8.1 Light Flak Prototype Vehicle (VFW-L) Mounting Either, Quadruple, 2 cm Flak 38 or 3.7 cm Flak 43 weapons

In September 1943, the Ordnance Master General/Flak V/IV, requested both Krupp and Rheinmetall-Borsig to submit designs for a light, armored self propelled gun-carriage. It was stipulated however, that this vehicle be armed with either 3.7 cm Flak 36 (equipment no. 338 V 4, later 3.7 cm Flak 43) or quadruple 2 cm Flak 38 weapon systems. Combined weight of weapons, ammunition and seven-man crew was estimated at approx. 4.5 tons. It was proposed to use the chassis of the prototype reconnaissance tank "Luchs" (VK 1303) as the system carrier. It had been requested that the construction of the superstructure should remain comparable with that of the heavy Flak prototype (for comparison see 4.8.2). It was to this effect that the Ordnance Master General/L/Flak forwarded to Krupp a design layout of the tracked "Luchs" tank, together with scale drawings of the VK 1602 "Leopard" reconnaissance tank for comparisons purposes. In response, on November 4th, 1942 Krupp submitted four designs for armored, self-propelled gun-carriages. Three of those designs covering the 3.7 cm Flak 36, Flak 43 and quadruple, 2 cm Flak 38 weapons. The fourth design showed the installation of a 10.5 cm, light field-howitzer, 43 mounted on the same chassis. Combat weight of the proposed vehicle was determined as twenty-five tons. It was foreseen that a maximum of integration of Leopard reconnaissance tank components would take place. Consideration had also been given to delay further development work on the heavy Flak prototype (VFW) from early 1943 onwards in order to accelerate development of the lighter (VFW-L) self-propelled Flak vehicle.

Cancellation of the Leopard reconnaissance tank project meant to revert to the use of Mk IV tank components.

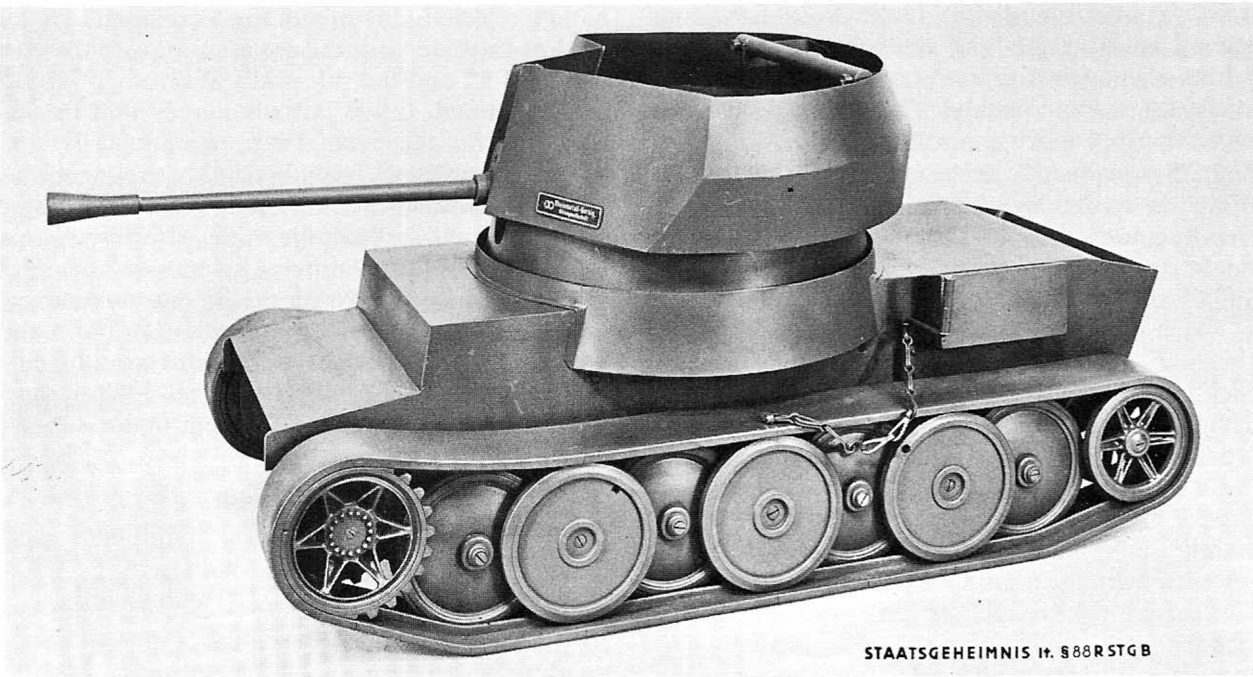
The following preliminary design guide lines were established:

Combat weight:	25 tons, maximum
Engine:	Maybach, HL 100 producing 400 HP (prototype vehicle with HL 90 – 360 HP)
Transmission:	ZF. SSG 76 (for series production eventually a newly developed ZF-AK 7-80)
Steering:	Single radius, Krupp steering unit
Running Gear/ Suspension:	Mk IV Tank
Speed:	45 to 50 km/h



Light Research Flak Vehicle (VFW-L)

The Light Research Flak Vehicle (VFW-L) configuration for 2 cm and 3.7 cm Flak weapons as proposed by the Reich Air Ministry. It was intended to integrate sub-assemblies and components of the VK 1303, Reconnaissance Tank (Luchs) wherever possible. The photographs of the model vehicle show both "march" and "engagement" positions.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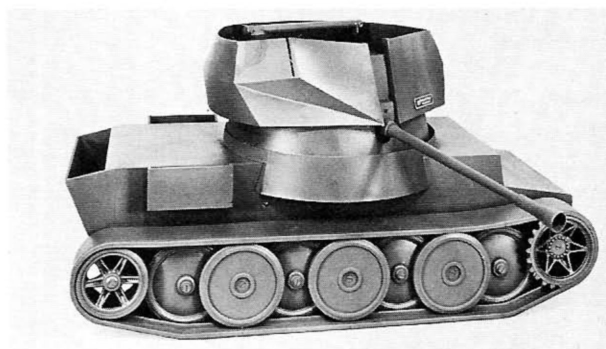


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As it was also intended to deploy these light anti-aircraft tanks armed with weapons of up to 5 cm caliber also against ground targets, they had to be ready for action quickly. The heaviest armored protection possible was also requested.
Both the quadruple, 2 cm and the single 3.7 cm "Flak" weapons, complete with their mounts were directly attached to the chassis of the carrier vehicle. In similar fashion to that of the 8.8 cm weapon, the 5.5 cm weapon had a special base plate fitted, to which, if required, support outriggers could be attached. This base plate was lowered into the deck of the hull. An auxiliary, makeshift hoisting device for disengaging the gun from the chassis in order not to expose the valuable chassis to enemy fire was considered adequate. For the removal of guns of up to 3.7 cm caliber it was proposed to dismantle them, heavier calibers would be removed complete with the assistance of jacks or cranes.
The carrier vehicle chassis remained structurally identical, irrespective of which weapons they carried. It was only the gun platforms themselves which differed, they existed in two different configurations, the "A" and the "B".

Configuration "A"
This was the common platform used for mounting either the 5 cm Flak 58 (Krupp) or 3.7 cm Flak 43 weapons. A centrally located, circular recess for accepting the pedestal of the 5 cm Flak mount was provided. Three further, smaller recesses were provided for the support plates of the triangularly formed base of the 3.7 cm Flak 43 mount, together with anchoring clamps for mount legs.

Configuration "B"
Intended as the universal mount for both the 3.7 cm Flak 36 and quadruple 2 cm Flak 38 weapons. Whereby a single, centrally positioned recess was provided for accepting the triangular pedestal of the gun mount, the pedestal being common to both weapons. The possible mounting of a 5 cm Flak 41 was to be investigated and if no major modifications proved necessary, undertaken. It was specified that the following thicknesses of armor were required: Front 50 mm, sides, rear 30 mm, roof and floor 16 mm, hinged platform sections a minimum of 2×10 mm. The thickness of the gun-shield was made dependant on the angle of inclination selected. Investigations were made if the field-of-traverse with the weapon at a minus elevation of 8° and the side-walls lowered 30° could be maintained. It was initially agreed that the installation for the 5 cm Flak, equipment Nr. 58 (Krupp) and the 3.7 cm Flak 43 weapon be the primary considerations. The Ordnance Master General/Flak stressed the high priority of this program and requested being given a definite date as to when he could expect the first production vehicle. Krupp received authorisation to build the first system from mild steel plate if it would facilitate delivery. By the end of October 1943, Krupp were requesting that the following major sub-assemblies be made available:

- ☐ Maybach, HL 90 Engine
- ☐ ZF-SSG 76, Transmission complete with Clutch, steering Unit and Final Drive
- ☐ Tracks, Type Kgs 61/500/130 with 95 links.

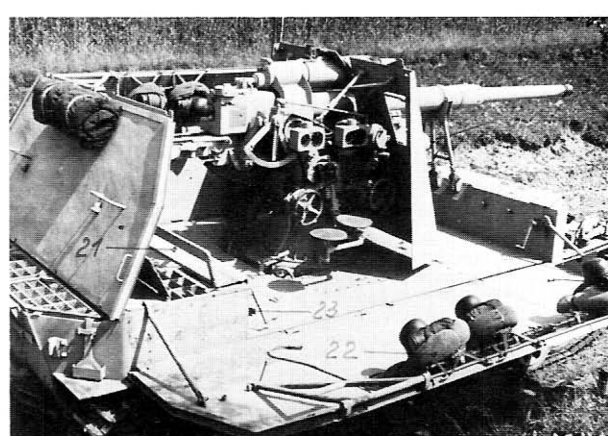
As the Kgs 61/500/130 tracks were already being fitted to both the prototype, VK 1601 and VK 1801 tanks, they were therefore, readily available.
At a meeting which the Ordnance Master General/Flak/E 4/VI, held on June 8th, 1943 the necessity of separating development of the light, self-propelled vehicle (VFW-L), from that of an all-round solution was established. Alternative "quicky" solutions were illustrated by the mounting the quadruple 2 cm Flak 38, on a standard Mk IV tank chassis, as well as on the newly developed (VFW-L) chassis. The order received by Krupp-Essen to built a prototype VFW-L chassis was transfered to Krupp-Gruson in Magdeburg.
Armament for the light, Flak (VFW-L) prototype was eventually finalised by the end of October, 1943. It was arranged that all further developments were to include either one of the following weapon systems, the 5.5 cm Flak, 3.7 cm Flak-mono or twin, or quadruple 2 cm Flak. The 5.5 cm Flak included in the program being that developed by Rheinmetall. As Krupp themselves had developed a 5.5 cm weapon, they naturally tried very hard to ensure that it was also included in the program. In mid-1944, as Krupp-Gruson were in the process of constructing the light, (VFW-L) Flak vehicle, they received orders from the Army Ordnance Office, Wa Prüf 6 to abandon all further work on it.

4.8.2 Heavy Prototype Flak Vehicle (VFW) carrying 8.8 cm Flak 38 or 41 Guns

The development of a heavy, anti-aircraft tank which was undertaken from 1942 onwards, was based upon an earlier development. This earlier program for 8.8 cm weapons (Pz Sfl.) mounted on a special chassis had originally been initiated by the Army Ordnance Office, Wa Prüf 6, in the Autumn of 1941. Now the intentiòn was that such a development would be an improvement on and eventually replace the 8.8 cm Flak 37 mounted on the eighteen ton half-track tractor. Frontal armor was required to be 20 mm thick, the sides 14.5 mm. It was planned that the central section where the longitudinal and lateral beams converged would provide a sufficiently rigid base structure for mounting the 8.8 cm Flak 37 weapons. Hinged, lowerable platforms were provided at each side and the rear, these could be locked in either of three positions.

- ☐ Vertically providing combined with the gun-shield an armored box, 1500 mm high. Whereby the traverse of the gun was limited to an arc of 40°.

As early as 1941, Krupp presented the first prototype of the heavy, research Flak vehicle. This carried the 8.8 cm Flak 37 weapon as armament. With this special development, the side walls of the armored superstructure were lowered when ready for action. The photos show the vehicle with both partially and completely lowered sides of the fighting compartment.

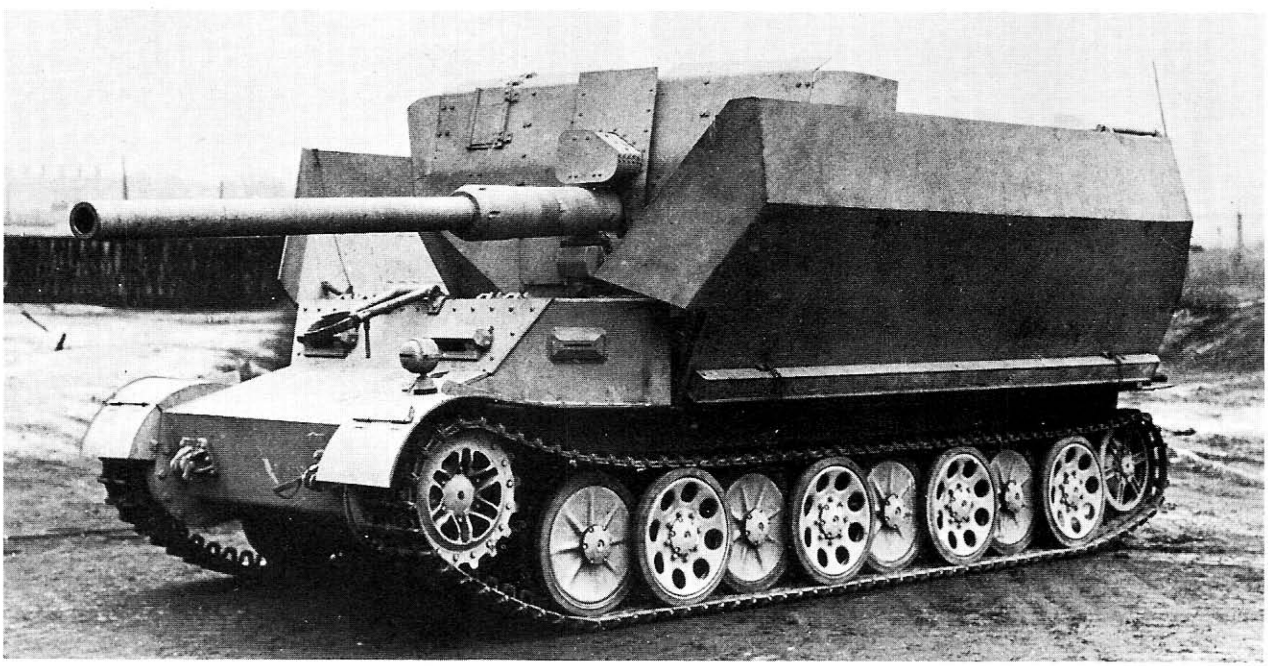


- ☐ or with the side sections lowered outwards to an angle of 30°, where at elevations of +10° or more the weapon could be traversed throughout a full 360°.
- ☐ Alternatively with these sections lowered completely where the gun could be fully traversed and lowered to a minus elevation of 3°.

Both engine and cooling system were located at the rear of the vehicle. The cooling system being designed to cope with ambient temperatures of up +45°.
The Maybach, 12 cylinders, HL 90, petrol engine produced 360 HP at 3,600 r.p.m. A triple sectioned drive shaft transferring power from the rear mounted engine to the gearbox and steering at the front. Zahnradfabrik-Friedrichshafen's, semi-automatic SMG 90 transmission changed gear using compressed air. A three-plate dry clutch with Jurid lining was flanged to the gear-box housing. For steering a Henschel-cross-drive, type L 320-C gear unit was fitted, the driver using a steering wheel.
An armored, spur-geared final drive was bolted to the hull from the outside, which also served as the bearing for the drive sprocket. At each side of the hull, the running gear was composed of four pairs of road wheels. Each pair were secured to the hull

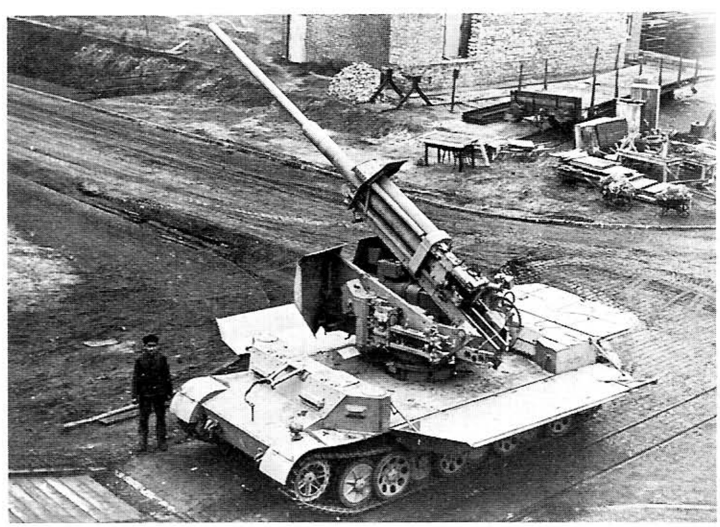
The picture shows the modified research Flak vehicle in the "march" position. The armored superstructure was roofless.

Research Flak Vehicle with sides opened 30° for ground target engagement.



Minimum lateral weapon elevation with side walls at the 30° setting.

With the sides in their upright position, umlimited weapon elevation was only possible at the twelve-o-clock position.



Only when the side walls were lowered to their horizontal positions was it possible to fully traverse the 8.8 cm gun through a full 360°.

The photograph shows the maximum elevation of the 8.8 cm Flak, mounted on the heavy research Flak vehicle.

via cranked arms. The forward cranked arms at each side were tensioned by leaf springs, one end of which was coupled with the rearmost cranked arm by a strut. Upward bouncing movement was inhibited by using bump-stops. Combat weight was twenty-four tons, the fuel supply of six-hundred liters being contained in four tanks at the centre of the vehicle, below the gun.

Discussions held by the Ordnance Master General, Flak/E 4 with Krupp, concerning modification of the vehicle in accord with newer requirements took place in September 1942. At this same meeting Krupp proposed that tank components expected to go into production within the foreseeable future, be incorporated within the vehicle, these included:

- ☐ track and suspension of the Panther tank, replacing those of the Leopard Reconnaissance Tank which had been contemplated earlier, as the larger diameter road wheels of the Leopard meant a 100 mm increase in the firing height.
- ☐ A Maybach, HL 157 petrol engine producing 550 HP (from Leopard).
- ☐ Either a Leopard type transmission, or development of a new alternative by Krupp themselves, necessitated due to the long tracks contact area with the ground.

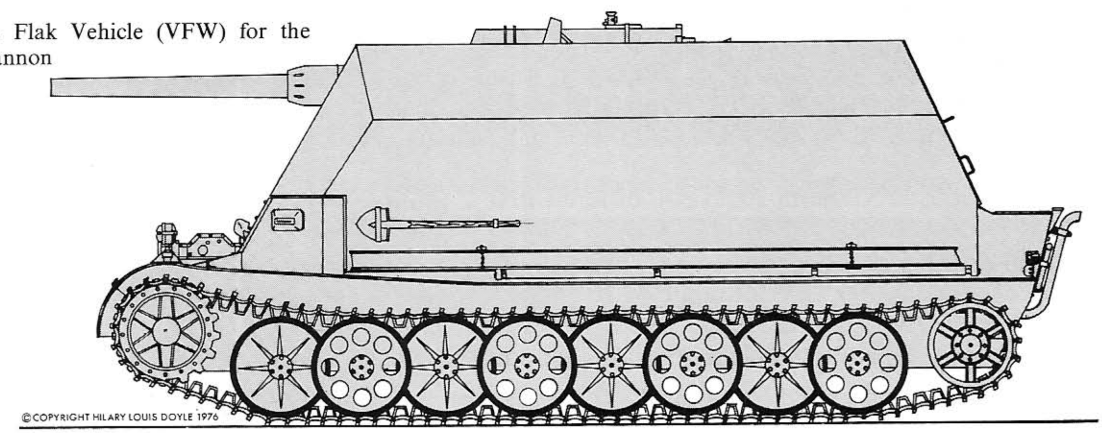
These various modifications led to the combat weight increasing to thirty-one tons and the firing height to 2,450 mm.

Krupp reported that with the first Flak prototype (VFW), the SMG 90 transmission, L 320 C steering-gear combination broke down so often that only a rather mediocre standard of automotive performance could be achieved. Whereby, Krupp alternatively suggested that the well-proven, ZF-SSG 76 transmission from the Mk III and IV tank be used, combined with a single-radius steering they themselves had designed. L/Flak agreed to this proposal. On the second prototype, Flak 2 vehicle incorporating Panther components, the lateral, hinged, armor plate sections were to be arranged in a manner which would guarantee the gun-crew some partial protection. As inclusion of the Panther components meant no structional modifications were necessary to the superstructure, it was decided, early in 1943, that the proposed changes be delayed until more data been collated from further trials with the first prototype.

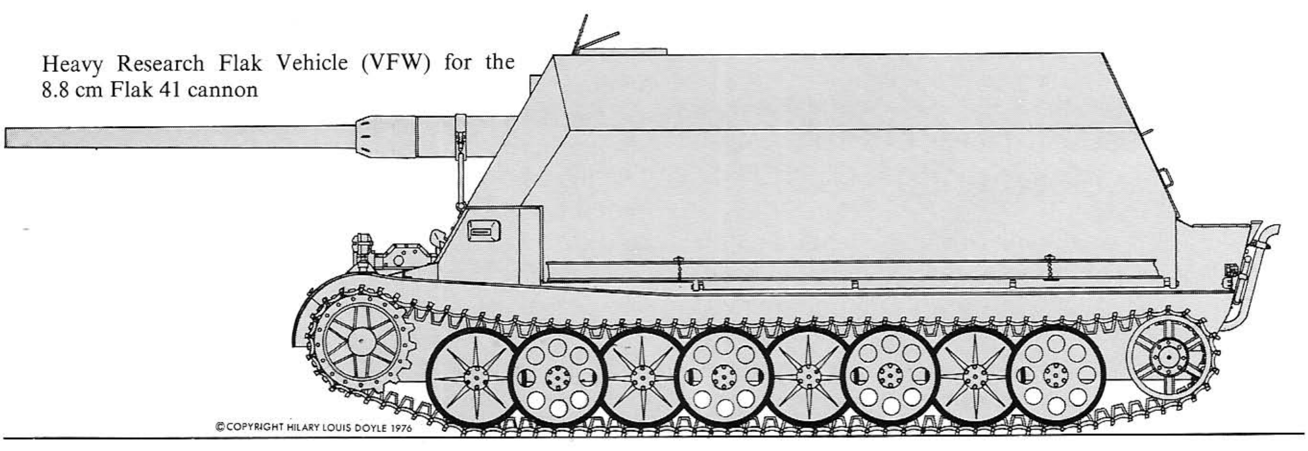
In October 1943, the Reich Air Ministry, Ordnance Master General/Flak, issued orders indicating that the proposed development of the new Mk 2 Panther tank should also serve as the basis for the VFW 2 vehicle design. After which Inspectorate 6, requested that the Panther 1 tank which they had provided was to be returned. Meanwhile no final decision would be made concerning development of a new VFW 2 vehicle, until the results of trials with the VFW 1 prototype on November 20th, 1943 at the Army Training Grounds, Bad Kühlungsborn had been evaluated. As history shows the Mk 2 Panther never entered production. The decision to cancel all further development of the VFW 2 vehicle occurred in December 1943.

The original contract for developing the heavy, self-propelled, Flak gun-carriage (VFW 2) (Construction Contract DE 0084-6715/42) was abandoned in favor of the lighter version (VFW-L) (Construction Contract DE 0084-6717/42) development.
Irrespective of this decision however, the prototype VFW 1, Flak vehicle was still subject to intensive trials by a variety of other military commands and agencies. It was armed with an 8.8 cm Flak 37 cannon. Whereas, the original VFW 1 carried thirty-six rounds of ready ammunition onboard, after it had been modified to carry the 8.8 cm Flak 41 in 1944, this was increased to forty-eight rounds. The Henschel cross-drive steering was replaced by a single radius, Krupp steering gear, the semi-automatic, SMG 90 transmission removed in favor of the SSG 76, transmission from ZF.
After modfication the systems combat weight was twenty-six tons.
Test firings with both anti-aircraft tanks and self-propelled guns took place on the 8th and 9th of March, 1944. These firing trials being carried out at the Demonstration and Training School Facility, of the Army Anti-Aircraft Artillery in Oxbøl, Denmark.
Road tests with the 8.8 cm, anti-aircraft tank, extended over a distance of approximately twenty-five kilometers of mixed terrain (sand dunes) and roads proved extremely positive. The good steering characteristics of the Krupp-single radius gear, inspite of its unfavorable 1.5 ratio, enabled steady speeds of between 40 and 50 km/h. This on both narrow and very winding roads. Without having to use the full power from the engine, speeds of up to 60 km/h were reached and maintained on the

Heavy Research Flak Vehicle (VFW) for the 8.8 cm Flak 37 cannon



Heavy Research Flak Vehicle (VFW) for the 8.8 cm Flak 41 cannon



more level sections. No pitching motion was experienced due to the rather long lenght of track in contact with the ground.

Gunnery trials with the 8.8 cm Heavy Anti-Aircraft tank proved satisfactory in one respect only, that of the vehicle stability. A simple suspension locking mechanism which Krupp demonstrated was considered superfluos. The firing results scored by older prototype weapon from the Hillersleben Artillery Ranges proved to be totally unsatisfactory, the gun-laying device having failed completely. Series production of this vehicle, at this time, was unthinkable as no remote means, either optical or by radio existed by which the command vehicles could maintain contact with the gunnery vehicles. Field-telephone type communications being rejected on the grounds that they considerably limited a batteries mobility and deployment. As all the trials carried out until this time had been purely works trials, it was considered unnecessary that official trials be initiated.

Therefore the heavy Flak (VFW-1) prototype was returned by the demonstration staff, in mid-1944, to the Krupp-Gruson company. Whereafter, the Ordnance Master General-Flak-E 4, ordered that Krupp replace the 8.8 cm Flak 41 with an 8.8 cm Flak 37 weapon which had been procured by Inspectorate 3. Further development of the heavy Flak prototype was discontinued, mainly due to the disapproval of it by the Commanding General of Armored Forces.

4.9 Multi-Purpose Vehicle Studies (Joint Porsche, Rheinmetall-Borsig Developments)

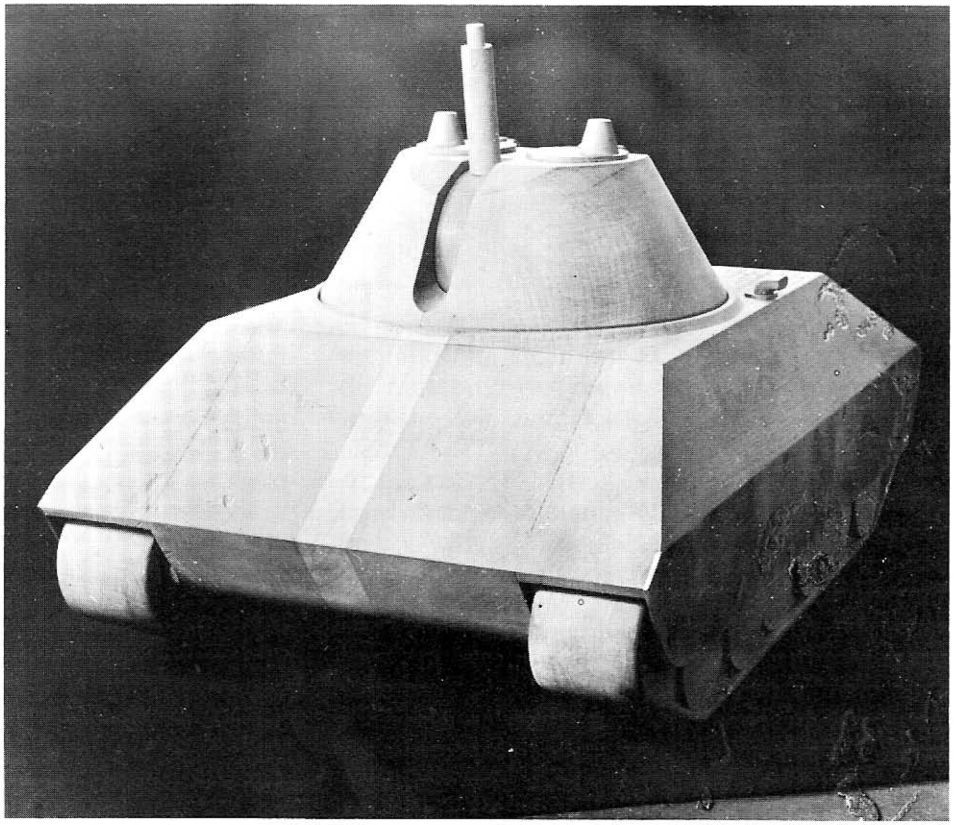
Influenced no doubt by wartime events and the ever increasing shortage of raw materials, a series of interesting designs for light, armored vehicles were drawn up by the company, Dr.-Ing. h.c. F. Porsche KG. These designs had been commissioned by Director Kniepkamp of the Army Ordnance Office, Wa Prüf 6. The preparatory work having commenced in May 1943. Whereby, Porsche had been assigned responsibility for all automotive oriented aspects of the designs, Rheinmetall-Borsig the one concerning the weapons. Two basic vehicle concepts were studied, one for a light tank, armed with a fully automatic 5.5 cm caliber cannon, for deployment against both air and ground targets. The second vehicle, a smaller heavier tank was to be armed with a 10.5 cm caliber, field-howitzer 43 and a 3 cm caliber, automatic, Flak 108 cannon.

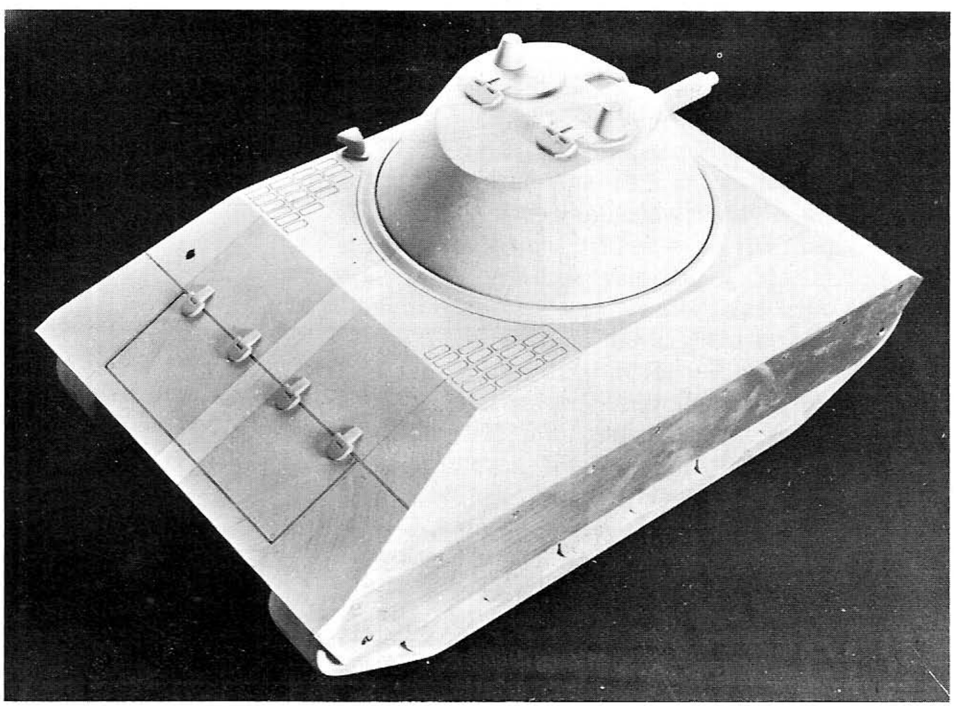
4.9.1 Light Tank, deployable against Air and Ground Targets, with Fully-Automatic Cannon

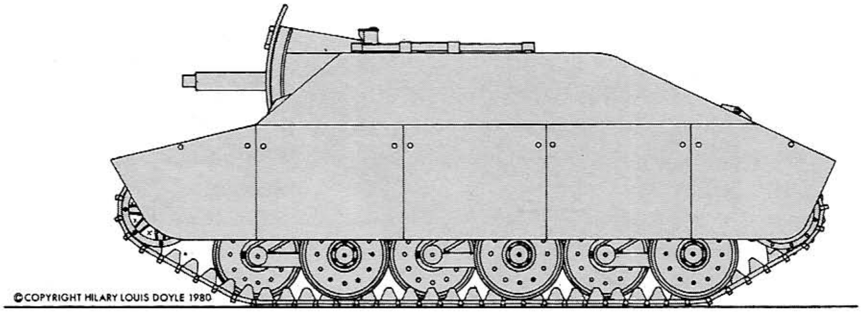
Porsche's first vehicle concept which was type designated 245, was a fifteen-ton combat vehicle with a three-man crew. Frontal armor was up to 80 mm thick, with the sides, rear and floor of the hull being constructed from 30 mm thick armor plate. The transverse, rear-mounted, six cylinder, Maybach HL 116 petrol engine having an output of 300 HP. This engine combined with a Voith torque converter providing the vehicle with a maximum speed of 58 km/h. The running-gear at each side was composed of six, 660 mm dia. staggered road wheels mounted on truncated cone springs. 500 mm wide tracks were fitted with a surface contact length of 2,270 mm. Track width of the vehicle was 2,560 mm, steering ratio was 0,9 and specific ground pressure 0,66 kg/cm².

Rheinmetall-Borsig proposed an automatic, 5,5 cm caliber, Mk 112 cannon with a muzzle velocity of six hundred meters per second as main armament. This weapon weighed 600 kgs. and was belt-fed, an on-board supply of three hundred rounds of ammunition was planned. Each round weighed 2,38 kgs and was 375 mm's long. It was intended that the weapon be deployable against both air and ground targets. When engaging ground targets with the turret roof closed, and the gun-shield slaved with the gun, the elevation range of the weapon was restricted to $\pm 10°$, traversing movement to 3° each side. When engaging aerial targets with the turret roof open and the gun-shield coupled with the vehicle the weapon could be ele-

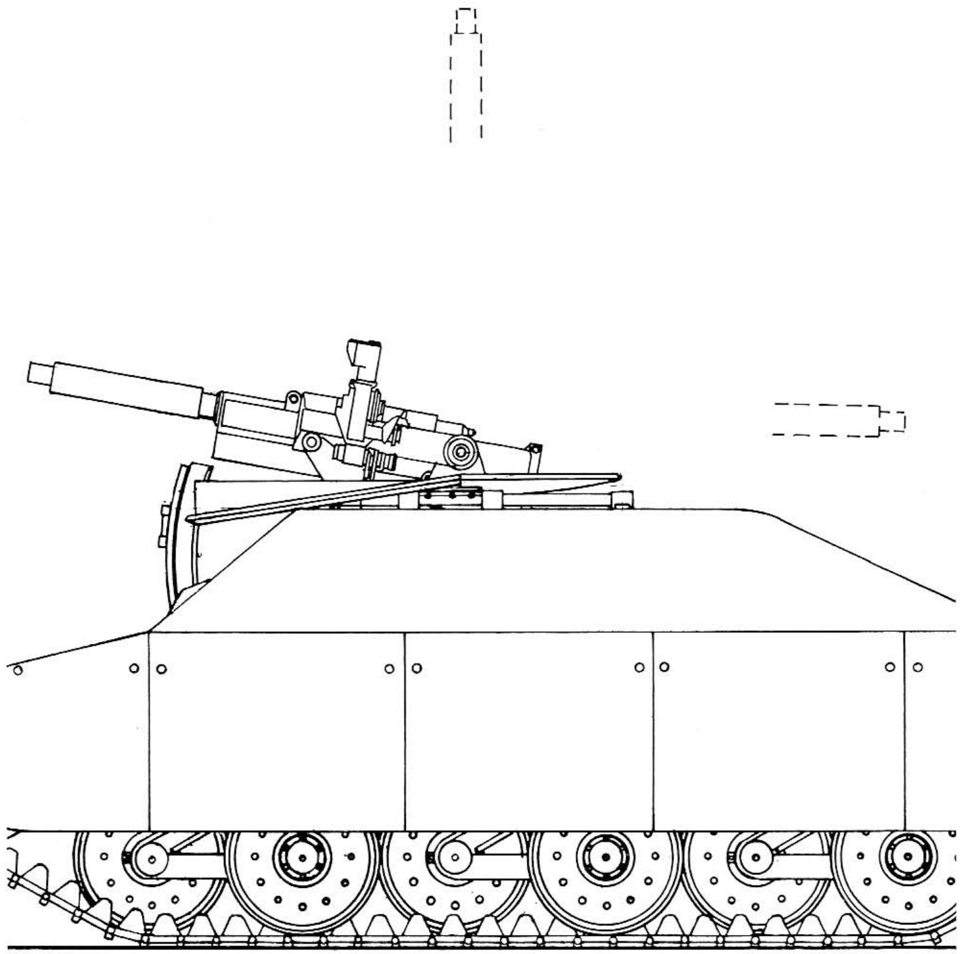
Wooden mock-up of a proposed light armored vehicle for engaging both ground and air targets, jointly designed by the Porsche and Rheinmetall-Borsig companies: It was to be armed with a fully automatic, 5.5 cm MK 112 cannon developed by Rheinmetall. The photographs show the front and rear views of the proposed vehicle. (Later designs show the turret concept was discarded.)







Light armored vehicle for deployment against both ground and air targets armed with an automatic 5.5 cm cannon



Drawing shows the weapon elevated to engage aerial targets

vated from 0° to +90°, with a full 360° of traverse. For sighting ground targets, installation of a (W.Z.F 10×7°) persiscope was planned, with a second D.O.K c/4 1×40° periscope being provided for use against aerial targets.

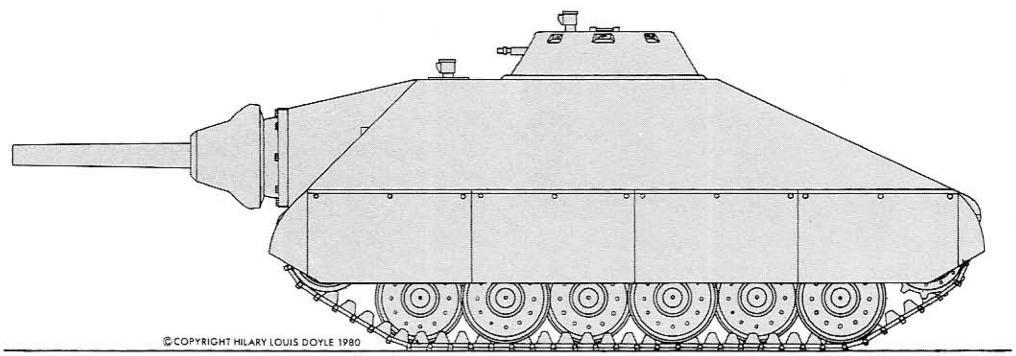
In October 1943, Rheinmetall-Borsig submitted their concept for an improved version of this light tank for consideration. By incorporating cast steel frontal armor 60 mm thick, together with 40 mm side and 20 mm hull rear and floor armor, combat weight had increased to 18,5 tons. Other alternative armor thicknesses of 50, 30, 12 and 12 mm's were also suggested in order to reduce the combat weight to 16,5 tons. Tracks 450 m wide with a surface contact length of 2920 mm were also proposed, with the vehicle track width reduced to 2350 mm, steering ratio was 1,25, specific ground pressure being 0,62 kg/cm². Road wheel diameters were also smaller at 600 mm's, ground clearance had been increased from 400 to 450 mm's. Transversely mounted in the rear of the hull was an air-cooled, type 101, 10 cylinder petrol engine with an output of 316 HP. It was estimated that this would give the vehicle a top speed of 65 km/h. This engine did in fact originate from Porsche's Tiger development programm.

It was intended that this light tank with its three-man crew be dually deployable against either air or ground targets. Although very intensively and thoroughly studied by Wa Prüf 6 of the Army Ordnance Office, no official development contract was placed with Rheinmetall-Borsig.

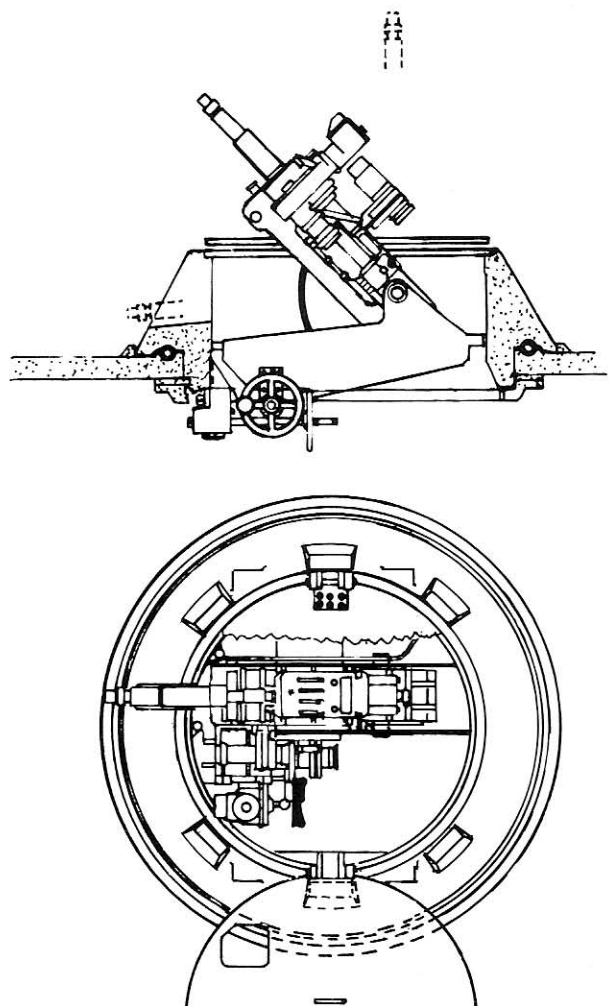
4.9.2 Heavy, Compact Tank with both 10,5 cm Light Field Howitzer 43 and 3 cm Automatic, type 108 Cannon

Two Porsche designs, dated July 1943, for the compact, heavy tank received the Porsche type numbers 250 and 255 respectively. The type 250 was planned to have hydraulic drive components, the 255 mechanical ones. Porsche designated both these vehicles internally as the Special Vehicle VI. In authentic documents dated February 1944, combat weight is stated as 26,6 tons. The original design, dated July 29th, 1943 foresaw frontal cast steel armor, 120 mm thick at the upper frontal section and 70 mm thick at the lower. Side armor some 80 mm thick and rear armor 70 mm thick was also planned. The floor plate of the hull with 30 to 40 mm thick armor plate provided adequate protection. Tracks 600 mm wide were proposed with a surface contact length of 2,750 mm, vehicle track width being 2,650 mm, resulting in a steering ratio of 1,04 and specific ground pressure of 0,5 kg/cm². The four-man crew were to be sited in the following locations; Driver to the front left of the hull, both the gunner and loader to the right with the commander left in the fighting compartment.
At the rear of the hull it was planned to install a transversely mounted, V-engine, transmitting its power with an angular drive to the fully-automatic, hydraulically operated, integrated transmission/steering gear, driving in turn the rear mounted final drive sprockets. This arrangement resulted in a comparitively small engine compartment. During trials, the originally foreseen, 10 cylinder, air-cooled engine was extended to 12 cylinders, with a total capacity of 18 liters. The anticipated 500 HP output from this engine was expected to result in the vehicle having a maximun speed of 57 km/h.

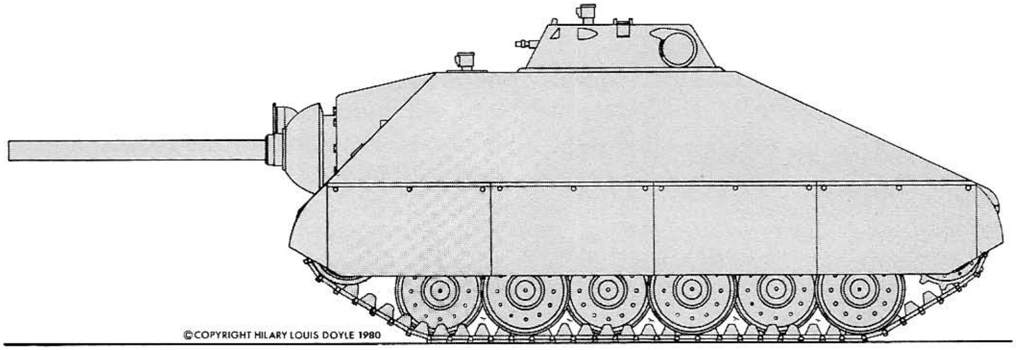
Six, 780 mm diameter, staggered, road wheels were planned in each running gear, all of which were sprung using truncated cone springs. Armament comprised one 10,5 cm caliber, light field howitzer 43, with a muzzle velocity of 600 meters/sec., and one 3 cm caliber, type 108 machine cannon with a muzzle velocity of 525 meters/sec. Weight of the 10,5 cm weapon was 2,100 kgs, that of the 3 cm weapon 300 kgs. On-board ammunition supply was fixed at forty-four rounds for the howitzer and seven hundred rounds for the cannon. The 905 mm long, 10,5 cm shells weighed 17,24 kgs. each, total weight of the 3 cm rounds being 500 kgs. Field of elevation of the howitzer ranged from –7° to +15° with a traverse movement of ±8°. The 3 cm belt-fed cannon was installed in a small turret sited alongside the commanders station. According to original documents from 1943, two different turret configurations, A and B had been suggested.



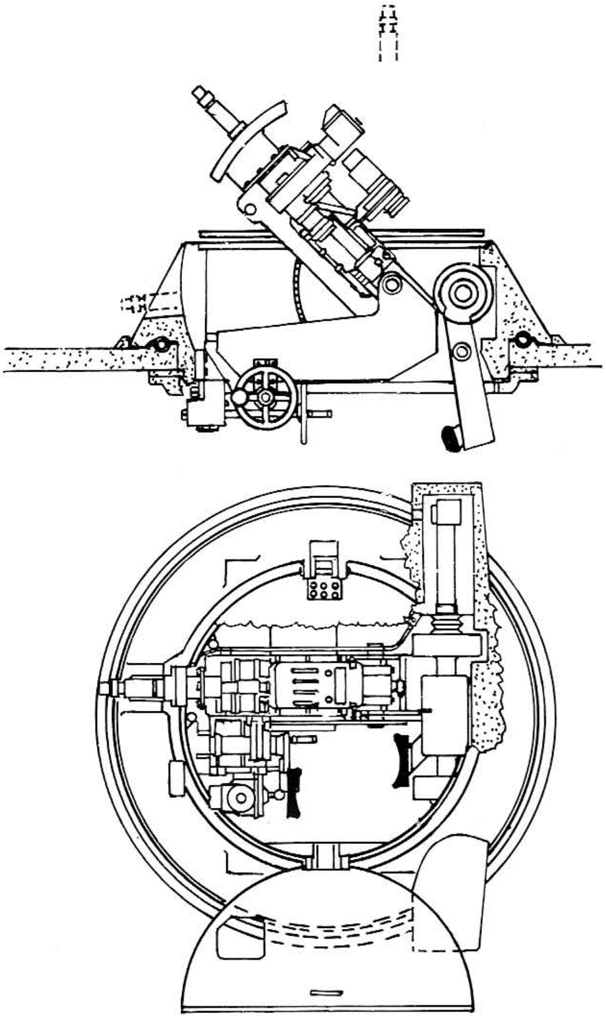
Compact, heavy tank armed with a 10.5 cm light Field Howitzer FH 43 and 3 cm, fully automatic 108 machine cannon



Side and plan views of the 3 cm-MK 108 cannon when engaging aerial targets



Compact, heavy tank with 10 cm anti-tank launcher tube, 3 cm fully automatic machine cannon 108, infrared searchlight and range finder



Side and plan views of the 3 cm – MK 108 cannon when engaging aerial targets

Cupola A
- ☐ Not deployable against ground targets
- ☐ Deployable against aerial targets at elevations between +10° to +90° with full 360° traversing.

Cupola B
- ☐ Deployable against ground targets at elevations from –5° to +5°, with full 360° traversing.
- ☐ Deployable against aerial targets at elevations from –5° to +90° with full 360° traversing.

A revised lay-out concept from February 3rd, 1944 shows considerable alterations to the vehicle. Upper frontal armor had been reduced to 80 mm, lower to 60 mm. Side armor was reduced to 40 mm, but additional 20 mm auxiliary armored skirts had been added. Rear section armor was also thinner at 60 mm, only the hull floor plate thickness of between 30 to 40 mm remained unchanged.

Road wheel diameters had been reduced considerably to 620 mm dia, ground clearance was also reduced to 450 mm instead of 500 mm. Steering ratio had increased to 1,16 due to the reduced track width of 2,500 mm and increased track/surface contact of 2,900 mm. Tracks were reduced in width also, to 550 mm. Due to the proposed installation of recoilless (rigid) mounting for the 10,5 cm howitzer its supply of on-board ammunition could be increased to seventy-seven rounds. In contrast to which however the quantity of on-board ammunition for the 3 cm cannon was reduced by one hundred rounds to six-hundred. Combat weight inclusive of the four-man crew remained unchanged at 26,6 tons. No prototype of either of these tanks was ever manufactured.

4.9.3 Heavy, Compact Tank, with both 10 cm Anti-Tank Rocket-Launcher, 3 cm, automatic type 108 Cannon, Infrared Searchlight and Range Finder

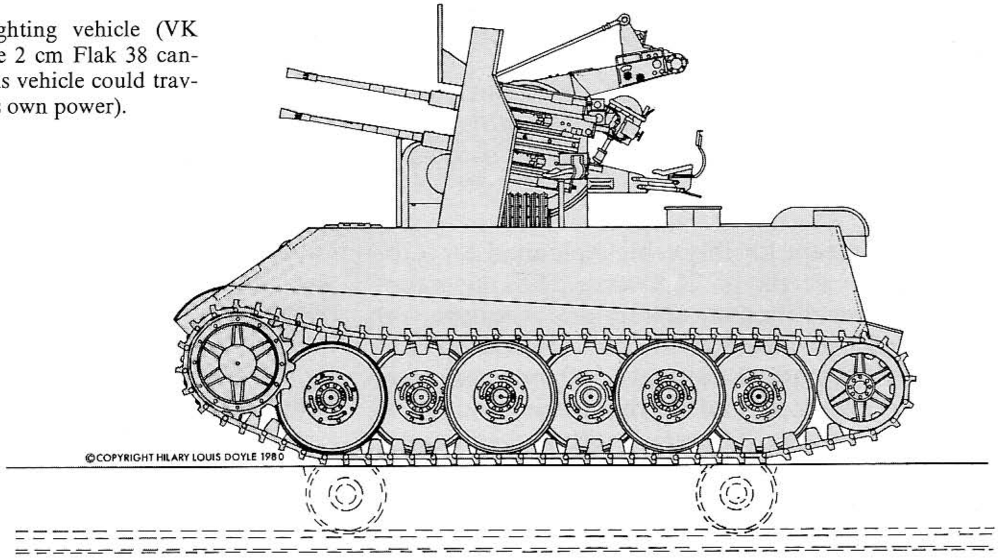
The Porsche company carried out a studie in April, 1944 with a recoilless anti-tank rocket launcher. This weapon weighed two tons in all, had a caliber of 10,5 cm and a muzzle velocity of nine hundred meters per second. On-board ammunition comprised fifty-six 10,5 cm projectiles and six hundred rounds of 3 cm ammunition. Range of elevation for the rocket launcher ranged from –7° to +15°, with limited field of ±10°. The single 3 cm Mk 108 cannon was mounted in a fully traversable cupola set into the hull roof. Battended down for deployment against enemy ground targets the cannon could only be elevated from –5° to +15°. Whereas with the superstructure roof and hatches open for engaging aerial targets, full traversing was maintained, field-of-elevation of the weapons increased from –5° to +90°. Combat weight inclusive of the four-man crew was twenty-six tons. The planned installation of both an infrared searchlight and range finder providing indication of new trends toward more highly developed technology. These trends were not fully realised however until many years later. Although development of anti-aircraft tanks was no longer being furthered by the Army Ordnance Office, during the latter years of the war due to the deteriorating military war situation and shortages of raw-materials, it is remarkable to note the large numbers of future oriented weapon concepts which had been instigated.

4.10 Study for a Multi-Purpose Armored Vehicle (VK 2801)

On the occasion of a meeting held on June 8th, 1943 Col. Walter from the Ordnance Master General-Flak-E 4/VI Office announced, that further to the continual requests made by his office, the Commanding General of Armored Forces, Col. Gen. Guderian had decided to initiate development of the so-called "Multi-Purpose Armored Vehicle" for light Flak applications.

This development was to be conducted under the auspices of the Army Ordnance Office, Wa Prüf 6. The project was allocated the number VK 2801. It was intended that the vehicle have a combat weight of twenty-eight tons and be capable of travelling at a maximum speed of 50 to 60 km/h.

Multi-purpose, armored fighting vehicle (VK 2801) armed with quadruple 2 cm Flak 38 cannon (it was intended that this vehicle could travel on railway tracks under its own power).



To participate within the development program were the companies, Alkett-Berlin-Borsigwalde, Daimler-Benz Berlin-Marienfelde and Krupp-Essen. Management responsibility for the project was assigned to Director Kniepkamp, Head of the Armored Vehicle Research Establishment. The engine originally intended for this vehicle, the Maybach HL 100, petrol engine was, in the opinion of Wa Prüf 6-F of the Army Ordnance Office, not powerful enough for this application. As an alternative the Project Manager proposed that the more powerful Daimler-Benz, MB 819, diesel engine be installed. Krupp raised objections to this suggestion on the grounds that the gearbox/transmission was yet untried and that a suitable steering gear had yet to be developed. Lt.Col. Schaede from the Reich Ministry for Armaments and Ammunition suggested the installation of an air-cooled engine.

Meanwhile, Krupp confirmed that using a six-wheeled running gear which they had developed with 700 mm diameter road-wheels, a steady speed of 30 km/h could be maintained, with a vehicle weighing twenty-six tons. Furthermore, six hundred millimeter wide tracks were planned as standard for all of the proposed configurations of the new vehicle.

As it was intended that series production commence in the Spring of 1945, it was decided to install the existing Maybach, HL 100 engine with an output of 400 HP in the new vehicle. This would be further augmented by including a ZF-SSG-76 transmission unit and a Krupp, single radius steering gear.

In July, 1943 the following development schedule was drawn up:

☐ Design	3 months
☐ Prototype Construction	6 months
☐ Pre-Series Planning	8 months
☐ Commence Series Production	April, 1945

The installation of a more powerful, unproven engine meant that this schedule could not be maintained, due to the time and necessity of developing a suitable new steering gear box. This would be based upon that designed for the Leopard Reconnaissance Tank. Wa Prüf 6-F of the Army Ordnance Office decided therefore the existing HL 100 engine, ZF-SSG-76 transmission and Krupp steering gear to be incorporated within the design of the new vehicle. A contract for manufacturing three to five prototype vehicles would be placed with and carried out by Krupp-Gruson of Magdeburg. Independantly however a vehicle develop-

ment using a more powerful powertrain was to be initiated.
Suggested armament was a 7,5 cm caliber, L/70 anti-tank gun, traversable trough 30° to right and left (15° each), with a field-of-elevation ranging from –8 to +20 degrees.

Krupp's concept for this vehicle planned for a total combat weight of 26,5 tons. They also presented three different running-gear concepts for consideration: a six-road wheel configuration with 600 mm dia. road wheels and 3,180 mm track/surface contact length, and alternative six-road wheel running gear with 700 mm dia road wheels and a track/surface contact length of 3,650 mm. Both of these configurations were intended for mounting, either the quadruple, 2 cm Flak 38 cannon or a simplified Mk IV turret. The third and final configuration was for a chassis with staggered, 800 mm dia. road wheels, and track/surface contact of 2,950 mm. Whereby two possible roles were considered for this configuration, firstly that of a tank destroyer, armed with the 7,5 cm, L/70 anti-tank gun. Or secondly that of an armored personnel carrier. Both these versions when fitted with the necessary wheels could use railway tracks for travelling. Combat weight for the quadruple, 2 cm Flak configuration was 24,7 tons. Armored protection was given as being 50 mm at the front, 30 mm at the sides and rear. Power-to-weight ratio was 15 HP/ton, maximum speed 60 km/h and the engine was mounted in front.

As a possible alternative power-pack, an air-cooled, type 12 LD 330 H, Argus engine, complete with semi-automatic Maybach-OLVAR OG 5511 transmission and Leopard cross-drive steering was proposed.

In place of the initially suggested MB 819 diesel engine, which in its tank configuration produced a maximum power output of 400 HP, Daimler-Benz proposed installing their MB 507 E engine. This diesel engine produced a total output of 650 HP at 2,000 r.p.m.

Wa Prüf 6 of the Army Ordnance Office, did not accept the proposal and insisted that an eight cylinder engine be specially developed from the 12 cylinder MB 507. The reason given being that the smaller engine would be easier to install in the limited space available.

Daimler-Benz's reluctance to undertake such a project was understandable by the fact, that it would have meant to completely re-design both crankcase and crankshaft. Daimler-Benz however was planning at this time a super-charged version of the existing engine.

By October, 1943 combat weight of the Krupp vehicle had already increased to thirty-three tons. In view of this the Army Ordnace Office, demanded that the Maybach, HL 230 engine from the Panther tank be installed in the vehicle, as it was 350 mm shorter in length than the Daimler-Benz, MB 507 diesel engine. A comparison of the torques delivered by each of these engines clearly confirmed the advantages offered by the diesel engine.

1. Maybach HL 230: $Md_{max.} = 167$ mkg; $n = 1{,}900$ r.p.m
2. Daimler-Benz MB 507: $Md_{max.} = 235$ mkg; $n = 1{,}625$ r.p.m.

Other advantages the Maybach Panther engine enjoyed however were: it was already in series production, and the standardised economic improvements for saving valuable, scarce raw materials had already been incorporated. Whereby, lighter metal alloys had been replaced by cast-iron, roller bearings with sliding bearings etc.

Due to this the various components intended for inclusion in the multi-purpose tank, were selected bearing in mind that the HL 230 petrol engine would be installed. After this had been completed it was planned to carry out a similar investigation with the MB 507 diesel engine.

The initial cancellation of the Multi-Purpose Armored Vehicle Project, VK 2801, announced on November, 8th 1943 was finalised by orders to the same effect, issued on May 8th 1944, by the Army Ordnance Office, Wa Prüf 6. The reason being that the vehicle was not longer included within the Emergency Program.

5. The German Armed Forces (Bundeswehr) – Army

Aerial defense of Central Europe, in particular the Federal Republic of Germany pose the following strategic complications:

- ☐ No forward area exists eastwards of the border to the German Democratic Republic.
- ☐ The very shallow depth of the area.
- ☐ The density of the population and continuing urbanisation expansion.
- ☐ The sensitivity of the all important supporting infrastructure to aerial attack and disruption.

The situation is further complicated by:

- ☐ The very short times needed for attacking and withdrawing from vital targets.
- ☐ The numerical superiority and availability of attack aircraft and target, at any time at any place and any altitude. This applies especially to attacks at low and very low altitudes.

In order to provide a viable stategic solution to the disadvantageous geographic military position and to off-set the very real and qualitative aerial threat to the West, Air Defense command has been centralised. The Allied Forces – interceptor fighters and surface-to-air Missile Batteries are subordinated to its command. The systematical deployment of Nike and Hawk Batteries to provide an in-depth defensive belt running from North to South was and remains the only effective counter to the threat.

However, in contrast to the effectiveness of these systems at the medium and very high altitudes, until now, all in all, there has been no comparably effective system to cover the low to very low altitudes. To point a verbal picture, the "game fence" was effective at its middle and upper levels. However in the nineteen sixties and seventies the lower to ground section was not secured, "game" was able to pass beneath ist.

Today, multi-role combat aircraft provide with their approach and attack tactics a means of penetrating this low-level gap in defenses. The intensive automation of avionics for navigation, target location and application of weapons, enables them to fly combat sorties in the worst weathers at low/very low altitudes following the terrain contours. These capabilities are enhanced by their weapons, ground dispersive bombs, minelets, delayed fall and "smart" bombs released at low-levels, anti-radiation missiles and other forms of "stand-off" weaponry, all of which can be used to disrupt or destroy the concentration of defensive anti-aircraft fire.

With the air forces of the Warsaw Pact States other mediums and equipment for electronics warfare (Eloka) for disrupting and misleading the air defense and equipments of the defenders are fully integrated within their operational attack squadrons.

Against this form of threat the armaments of the NATO Central European Armies possessed no satisfactory counter, irrespective of which weapon system is considered or which criteria is applied, be it operational, technical or personnel.

Land forces require therefore weapons and equipment to provide them with the means of retaining their freedom to operate during the most intensive combat conditions regardless of the aerial threat they are likely to encounter. This is the only effective way in which the operational commands can effectively protect vital plant and other key installations.

It is not only the substance of the problem which has played a mayor role in this respect, the rapidity of technological progress is self-explanatory as

to why the route to modern air defense has been so lengthy, when compared to that of other weapons and weapon systems. For the first time in the long history of air defense since the anti-ballon-cannon of 1870, todays weapon systems Gepard and Roland provide an effective air defense umbrella over the battle field.

Both systems are based upon the same basic military requirements:

- ☐ Extensive technical and tactical mobility.
- ☐ Sufficient armored and NBC protection.
- ☐ Autonomous, all weather capability.
- ☐ ECM resistance.
- ☐ Fast reaction times.
- ☐ Creditable systematic hit-probability whether from a round, burst of rounds or alternatively missile.
- ☐ Widest range of operational assurance by appling mode-redundancy facilities.

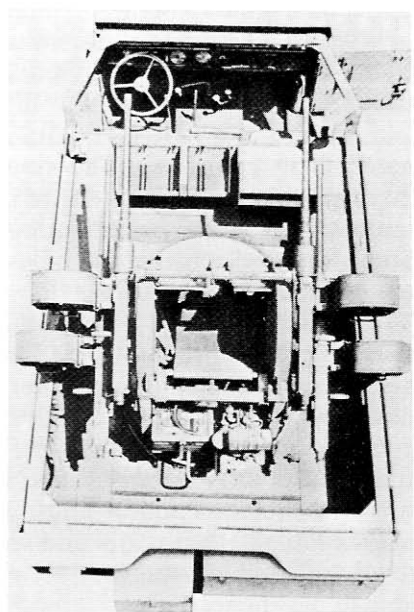
5.1 Initial Equipment of the German Forces with American Anti-Aircraft Tanks

After the formation of the German Forces, in 1956 the Army Air Defense Units were issued exclusively with American armored vehicles.

The few, quadruple, 12.7 mm anti-aircraft M 16 half-tracks which saw service with the newly formed German Forces were drawn from American war surplus stock. These systems were augmented by M 42, twin 40 mm Anti-Aircraft Tanks. The M 16 were withdrawn form service as early as 1958.

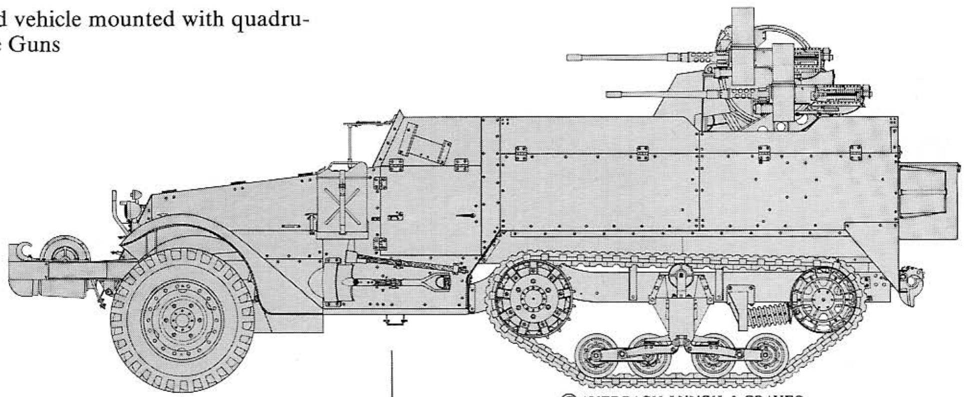
The American M 42 Anti-Aircraft Tank (T 141) was first introduced into service by the U.S. Army in 1953, as successor to the M 19 Anti-Aircraft Tank, they were withdrawn from service in 1961. The M 42 was at the time of its introduction into service with the German Forces, a very mobile vehicle with effective fire-power. However, even at

The initial equipping of the German Forces with American M 16 Half-Track vehicles used as self-propelled anti-aircraft systems mounting quadruple, 0.5″ Machine Guns.

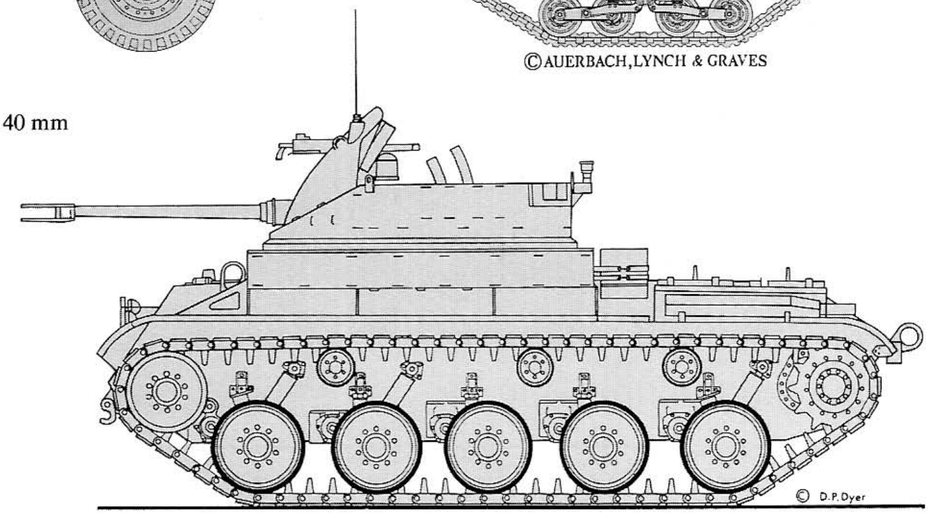


Photograph showing the plan view of the M 16 Half-Track vehicle.

M 16 Half-Track, self-propelled vehicle mounted with quadruple, 0.5″ Anti-Aircraft Machine Guns



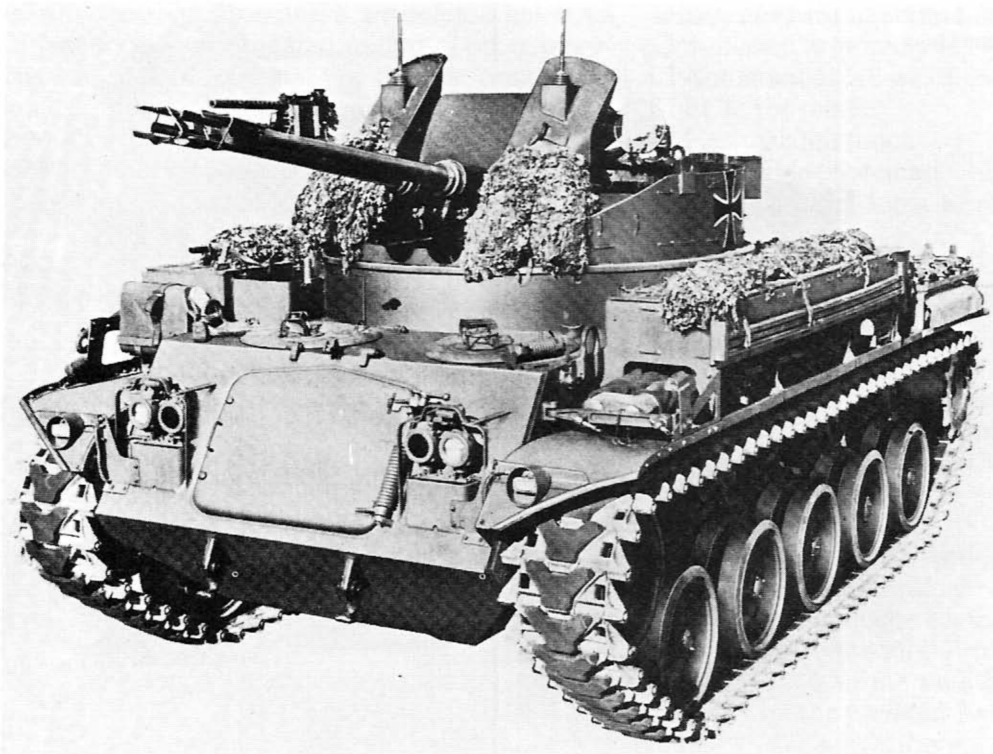
M 42 Anti-Aircraft Tank with twin 40 mm Anti-Aircraft Guns



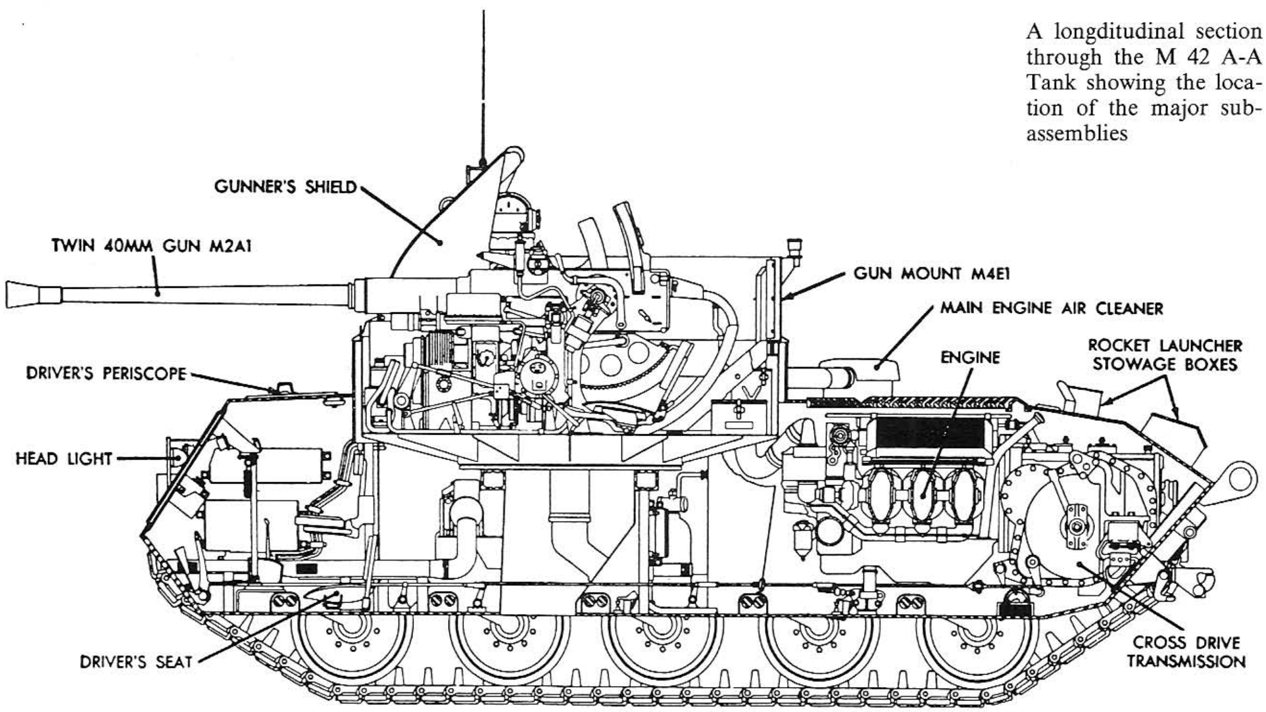
this time, the problem posed in providing effective air defense against low-flying aircraft had still not been satisfactorily resolved. From its introduction into service the Anti-Aircraft Tank was incapable of providing sufficient adequate air defense against the fighter bombers and reconnaissance aircraft of its day, mainly due to the inhibitions imposed by its guns range, optical fire control system and low slewing speed.

The M 42 Anti-Aircraft Tank was, as a member of the M 41 family of battle tanks, a light armored, fully tracked vehicle. Installed within its roofless turret were twin, 40 mm, Bofors Machine Cannon, Type L/60 M 2 A 1 mounted on a Type M 4 E 1 gun mount which included an integrated 7.62 mm MG Mount. In all the vehicle had a crew of six. Combat weight was 22.5 tons with a maximum road speed of 67 km/h. Both driver and commander were seated at the front of the vehicle with the commander additionally operating the radio. The centrally arranged fighting compartment served as both the lower basis for the gun mounting and as storage space for twelve boxes of 40 mm ammunition.

In all a total of four hundred and eighty rounds were carried on-board. The four man gun-crew were seated about the gun mounting. Installed at the rear of the vehicle was the six cylinder, air cooled, Type A0S 895-3, petrol engine manufactured by the Continental Co. together with gearbox. This engine had a displacement of 14,681 cm^3 and an output of 440 HP at 2,800 r.p.m. With a power to weight ratio of 19.6 HP per ton the A-A Tank possessed satisfactory mobility. An Allison CD 500-3 transmission was flanged to the flywheel side of the engine, it was composed of an hydraulic torque converter with three drive stages (March-Terrain-Reverse). The five pairs of

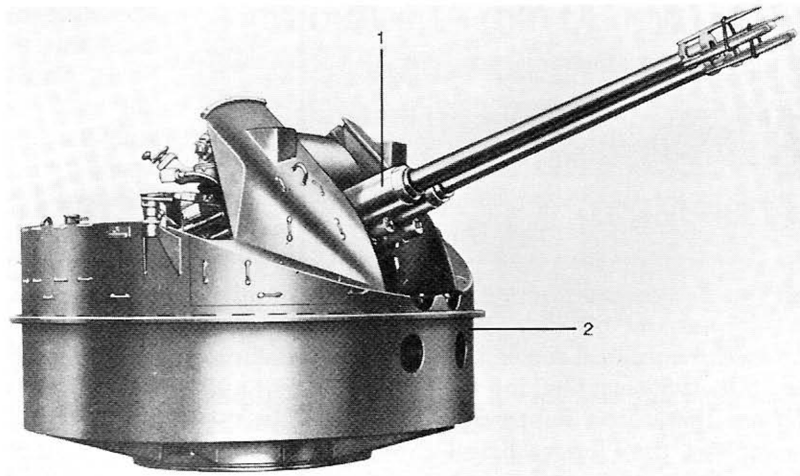


The American M 42 A-A Tank, 496 of which saw service with the German Forces. These were armed with twin 40 mm Anti-Aircraft Cannon.



A longditudinal section through the M 42 A-A Tank showing the location of the major subassemblies

The roofless M 42 Anti-Aircraft Tank Turret showing at position (1) the Twin 40 mm Cannon (2) the Turret well.



running gear wheels at each side were fully rubbered and suspended on transversely positioned torsion bars. The tracks were rubber padded and comprised of seventy-four links, each of which was 530 mm wided, hinged together. Three and one quarter meters of each track were in contact with the ground.

The twin, 40 mm Bofors Machine Cannon, M 2A1, were applied in the first instance by the U.S. Army to fill the gap in air defense which existed between the 90 mm Anti-Aircraft guns and the 12.7 mm Heavy Machine Guns. These 40 mm cannon could be elevated from –5° to +85°, their traverse was unlimited. For engaging aerial targets, a computive T 154 sight was combined with the Fire Control System installed for target tracking and weapon firing. Fire control was purely optical. Both weapons and turret were electro-hydraulically powered in both traverse and elevation. Loading of the weapons was achieved using the re-coil action of the vertically operated breech block mechanism, firing cadence was one hundred and twenty rounds per minute with a muzzle velocity of eight hundred and seventy-five meters per second. The overall length of the barrel, including the muzzle brake was 3,660 mm. Effective range reaching out to two thousand meters, although directed covering and harassment ground fire using high explosive incendiary ammunition was possible up to a range of four thousand eight hundred meters, the self-destructive range of the shell.

The various types of 40 mm ammunition which were available for use, were, with the exception of the armor piercing round all fitted with self-destruction fuses. These fuses were activated after a pre-determinded time of flight in order to avoid being a threat to one's own troops. The automatic loader held eight rounds. The cannon could fire High Explosive shells with Tracer (HE-T), Armor Piercing rounds. (AP-P), Armor Piercing Rounds with Tracer (AP-T). Additional practice and training rounds were also available.

Stowed within the Main-Engine Compartment was an auxiliary engine complete with generator which served not only to charge the batteries but also provided a power source for the turret drives and supplied the ancillary electrical equipment when the main engine wasn't running. The total fuel supply was only five hundred and thirty liters providing a relatively small operational range of one hundred and sixty kilometers. At the front and sides, the welded armor was 25 mm thick, the rear section 12.7 mm thick. The twin 40 mm A-A Tank, SP, M 42 was manufactured by the Cadillac Motor Car Division of General Motors. A total of four hundred and ninety-six systems saw service with the German Forces where they were assigned to the Divisional Anti-Aircraft Battalions of the Army, where they were known as the M 42 A-A Tank. These systems were withdrawn from service between 1976 to 1980, when they were replaced by the "Gepard" twin 35 mm Anti-Aircraft Tank.

5.2 Twin 30 mm Anti-Aircraft Turret mounted on the HS 30 Armored Infantry Carrier Chassis (Development Hispano Suiza/British Marc)

Department Blank, predecessors of the German Ministry of Defense originated their initial military requirement for a mobile air defense system, complete with an electronic fire control, on January 11th 1955, establishing fixed development guidelines thereto on September, 11th 1956. In this same year, the Geneva based company Hispano-Suiza, now a subsidiary of Oerlikon-Contraves of Zurich, presented a wooden mock-up of their 30 mm twin gunned, HS 831 Anti-Aircraft Turret complete with optical fire control. This turret was presented mounted on the HS 30 Armored Infantry Vehicle (Type A 14) Chassis which was still in process of being developed.

In July 1957 the military requirements for a weapon system with calibers of between 20 mm and 40 mm, mounted on an armored infantry vehicle chassis were finalized. Discussions followed with Hispano-Suiza concerning the development and delivery of eight prototypes. This led to a contract being signed in March, 1958 for the delivery of one wooden mock-up, weapons and ammunition. Differences between Hispano-Suiza and the Ministry of Defense, compelled the German Minister of Defense in July, 1958 to discontinue all further development.

Mid-1959 the suspension against Hispano-Suiza was lifted. From 1961 until 1963 both the companies British Manufacture and Research Ltd. (British Marc) of Grantham, a subsidiary of Hispano-Suiza and the Rheinmetall Co. of Düsseldorf worked upon development contracts which they had received from the German MoD, which included each company manufacturing two prototype systems.
Both companies had been instructed to incorporate the identical Radar* fire control system which was capable of sector target detection. This equipment was manufactured by the British company Elliot. An additional computer unit for facilitating fully automatic gun laying was also included in both concepts.

The type HS 831 Machine Cannon manufactured by Hispano-Suiza was a positively locked, gas operated weapon which had a cadence of 650 rounds-per-minute.

On November 19th 1963, a commission of German Ministry of Defense electronic experts exposed various deficiencies in the British-Marc development which led to the systems electronics not meeting the specifications which had been established, furthermore these deficiencies rendered the system unsuitable for trials purposes. The most critically decisive sub-system being the Elliot Cos. radar unit, the range of which was drastically inhibited by heavy rainfall. Further development by British Marc was discontinued and the protoype promised for delivery in March 1964 was not accepted.

5.3 Twin 30 mm Anti-Aircraft Turret mounted on an Armored Infantry Carrier Chassis (Development Rheinmetall/Rheinstahl Hanomag)

On August 12th, 1958, the, as it was then known, Technology Department (Armaments) of the German Ministry of Defense asked the Rheinmetall Co. to participate in the 30 mm Anti-Aircraft Tank development. In August 1958 the development for an Anti-Aircraft System utilising an Armored Infantry Fighting Vehicle chassis as carrier and incorporating rapid fire cannon with caliber of between 20 mm to 40 mm was resurrected. Previous developments having been interrupted at short notice due to budgetary problems. Early in 1959 Rheinmetall began working on their study concepts for an Anti-Aircraft Tank, the concept of which included the integration of a radar fire con-

* Radar = Radio Detection and Ranging

trol system. It was required that the carrier vehicle for the proposed system should be the chassis of the new armored infantry fighting vehicle which was currently being developed.

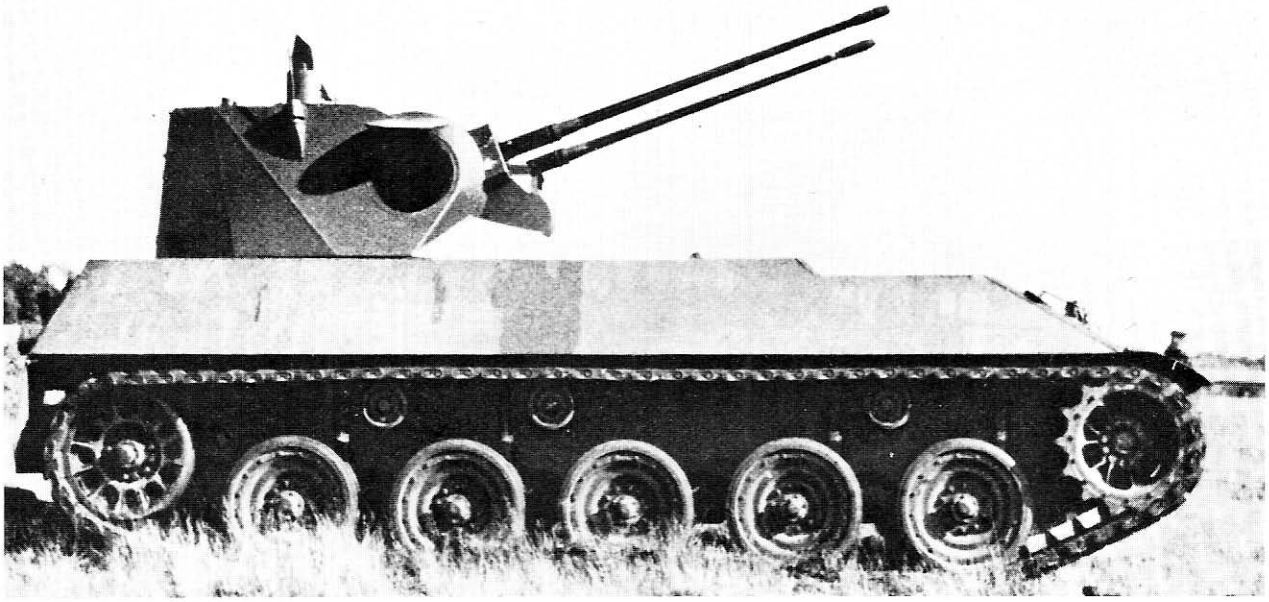
This decision to further the application of the new chassis was initiated by military requirements which had been established by the Army General Staff on September 7th 1959, whereby the new vehicle was planned as being the successor to the HS 30 armored infantry fighting vehicle. The requirements for the Anti-Aircraft Tank remained in some respects the same as those of the HS 30, including amongst other things:

- ☐ twin 30 mm Weapon System
- ☐ Fire control radar capable of sector target detection
- ☐ Lead angle computer
- ☐ Total turret weight not in excess of 5 t
- ☐ Complete system weight of not more than 20 t.

From the already comprehensive development of New Armored Infantry Fighting Vehicle Program later known as the "Marder", Rheinstahl-Hano-

Hispano Suiza proposed 30 mm twin gun based upon the chassis of the APC HS 30

30 mm twin gun based upon the new APC of the Bundeswehr. Development Rheinmetall



mag of Hannover, delivered between 1962 and 1964, three prototype chassis. The first of which was the RU (Ruhrstahl) 221, followed by the RU 222 and RU 243. All of which were powered by MTU, 833 series, front-wheel drive, V-6 engines with an output of 600 HP. Both prototypes 221 and 222 engines were rear mounted, whereas the RU 243 engine was located amidships. The ZF, Type 4 HP-180 transmission was used in all three prototypes. Entrance to the vehicles for the crew was via rear doors. On April 4th, 1963, Rheinmetall announced that the series price for the 30 mm Anti-Aircraft Tank was 1.5 million DM. Within the scope of the works trials the first firing trials took place on August 15th 1963. As ordnance two Hispano-Suiza, 30 mm Type HS 831 L machine cannon were used. These weapons each had a cadence of six hundred and fifty rounds per minute, muzzle velocity was 1,080 meters/sec.

An initial inspection by the Procurement Agency uncovered far reaching constructional deficiencies in the weapon system which made questionable whether the system was at all suitable for military application. The first of the two prototypes fitted with radar equipment (Elliot) underwent totally unsuccessful works trials, the second prototype, less radar was transferred to the No. 91 Military Proving Grounds on September 23rd 1964, for weapon systems trials. On December 12th 1964, the German Procurement Authorities WM I 2 drew up an intermediate conclusion of the development project which established the following facts:

- ☐ the Rheinmetall development had not led to any positive results
- ☐ the Elliot Co.'s Radar Fire Control was useless, its development incomplete and unable to meet the requirements

The MBT 70, a German-American Joint Development which never went into produktion.

☐ the individual crew stations were so cramped that they were totally unserviceable
☐ the new armored Infantry Fighting vehicle chassis was unsuitable for its proposed Anti-Aircraft Tank role.

In improving the turret's armor and the increased volume of the newly designed fire control system resulted in the turret's weight rising to 6.6 tons. At the end of 1964 the Federal Procurement Agency (BWB) therefore cancelled all further development on the basis that no positive results were to be expected.

5.4 MBT-70 chassis/hull adaptation for an anti-aircraft gun turret (Study)

On May 30th, the German Ministry of Defense, T VII 2, decided that Krauss-Maffei should carry out a provisional study. The objective of this study was to determine whether or not the MBT 70-chassis would provide a suitable carrier vehicle for an anti-aircraft turret. This study was to include the anti-aircraft turret concepts which had been proposed by the Oerlikon and Rheinmetall companies. Furthermore this concept applied only to the gun-carrying vehicle and not to the proposed AA-Command/Surveillance system with surveillance radar. The operational range of the MBT 70 was to be retained. The spaced armor configuration of the MBT 70 could be disregarded. However the nuclear protection for the driver (who unlike in the MBT 70 concept was now seated in the hull and not in the turret) was to be established to the same standard as that of the turret. The study was also to include among other items:

☐ cost estimates for development and modifications to the MBT 70 chassis
☐ cost estimates for construction of two air defense Command/Surveillance prototyp vehicles complete with radar
☐ cost estimates for series-built chassis without turret
☐ price for mock-up 1:10 scale model.

When the MBT-70-program was discontinued toward the end of 1969, all further investigations in this direction became superfluous.

5.5 Anti-Aircraft Tank Developments mounted on the Leopard MBT chassis

The unsuitability of armored personnel carrier chassis for adaption as potential Anti-Aircraft Turret carriers due to the weights of the latter, was a lesson very effectively brought home to all concerned between the years 1958–1964. It was with this thought in mind that the German Minister of Defense, authorised on September 27th, 1965, utilisation of the heavier Leopard MBT chassis for such a purpose. Series production of Leopard having just commenced on September 9th.

In order to support the very urgent priority which military authorities had established for the introduction of the Anti-Aircraft Tanks into service, the Technical Department of the German Ministry of Defense made the following decisions: Firstly the 30 mm caliber previously selected would be retained, just as the HS 830 weapon system which was already available. Drawing upon past experiences, the system however required various improvements. Of particular importance in this respect was the provision of a digital fire control system. This would not only facilitate linear hit prognosis but would also enable quadratic extrapolation of engaging aerial targets flying curving flight paths.

Both technical and tactical problems involved were very thoroughly studied, particular attention being paid to the weight and stowage space need by the various sub-systems. Further studies followed whereby the aerial threats were assessed and the tactical application of the Anti-Aircraft Tanks evaluated. After all of these studies had been completed, an industrial consortium comprised of the Rheinmetall/AEG-Telefunken and Porsche companies received authorisation from the German Ministry of Defense to proceed with a concept proposal they had suggested earlier.

The Ministry of Defense stipulated however that the Surveillance and Identification equipments were to be totally separated and installed in another vehicle. Fire Control and Guns were to be mounted on other vehicles, the overall concept then being the formation of "battle groups", composed of one Command/Surveillance Tank leading and directing a group of Anti-Aircraft Artillery Tanks.

In competition to this "battle group" concept, a Swiss industrial consortium composed of Oerlikon-Contraves and Siemens-Albis and headed by Contraves presented their twin 35 mm Anti-Aircraft Tank Concept for consideration. An earlier version of which had been presented to the German Ministry of Defense as early as March, 1962, was rejected by the Army General Staff on the grounds that the 35 mm caliber was not a standard weapon.

As soon as the Leopard chassis was released for Anti-Aircraft Tank development, Oerlikon-Contraves investigated the possibilities of realising a fully autonomous Anti-Aircraft Tank turret. A turret in which Search Radar, Fire Control System (Radar Tracker and Optronics) twin, externally mounted guns and sufficient ammunition for approx. fifteen engagements could all be integrated. In a technical specification presented by Oerlikon-Contraves in 1966, the first possible solution for a fully autonomous Anti-Aircraft Tank was convincingly demonstrated.

However, AEG-Telefunken acknowledged that the "Marder" digital Fire Control System which they were in the process of developing was too large to be stowed within the turret. Furthermore, in their opinion, the possibility of installing a second radar within the same turret was extremely remote.

In order to assist the realisation of the Armies requirements for a fully autonomous Anti-Aircraft Tank a Ministerial Steering Committee composed of the T VII 2 (Management) T VI 5, T III 2 and II 6 Army General Staff departments decided to purchase two Oerlikon-Contraves Anti-Aircraft Tanks for study purposes.

On February 20th, 1967, the Inspector General of Army Air Defense Forces set up a Study Group, charged with the task of working out in detail, the Anti-Aircraft Tank "battle group" concept based upon the Rheinmetall (30 mm) system. When completed this concept was then to be compared with that of Oerlikon-Contraves (OC) (35 mm) both tactically and technically. First results of this phase of the study clearly indicated the advantages of the OC autonomous solution.

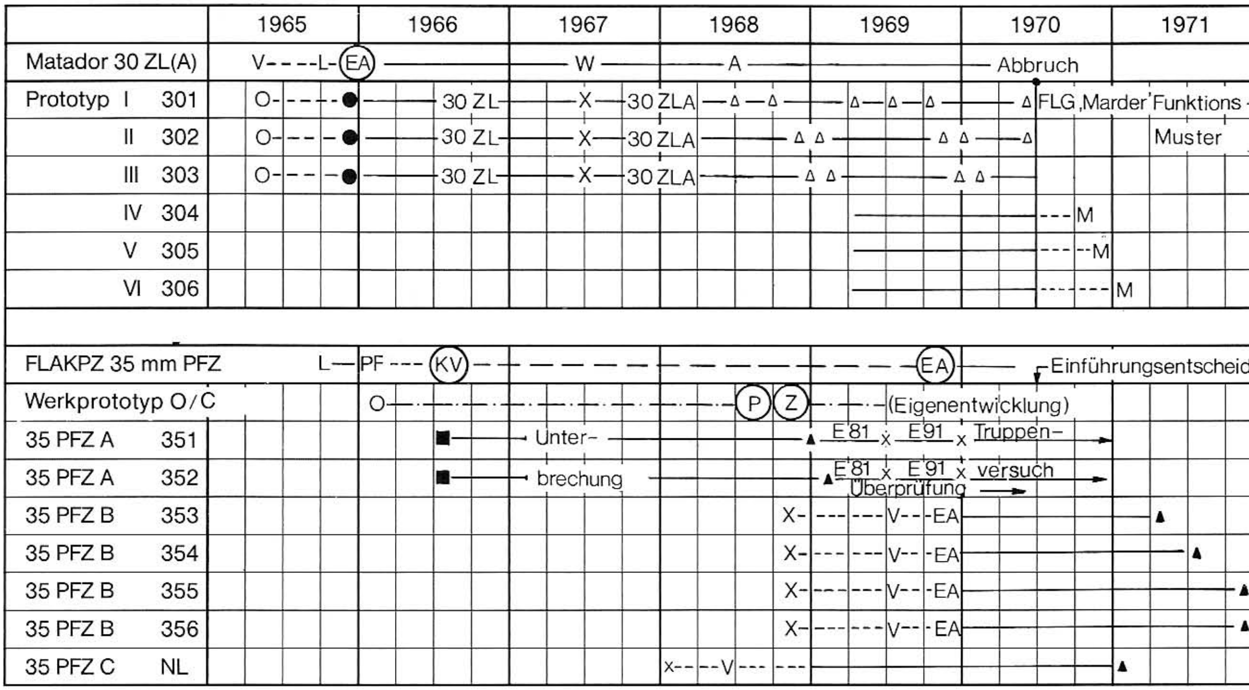
On the basis of these findings, on July 4th, 1967 the Steering Committee instructed the Procurement Agency (BWB) that all further development of the Rheinmetall Anti-Aircraft Tank, should only continue as an autonomous system. The combined interest shown by both the Inspector General of German Army Air Defense and the Royal Netherlands Army in the 35 mm Anti-Aircraft Tank motivated Departement T to contract the services of the Operational Research Group of the IABG* Co., to carry out a theoretical comparative study of both Anti-Aircraft Tank concepts.

Both 35 mm Anti-Aircraft Tanks which the German Government had purchased were inspected and accepted at the turn of 1968/69. With the cooperation of both German and Dutch soldiers it was possible to convince the authorities concerned that by optimising certain minor features a combat ready weapon system would result, no appreciative major risks were likely to occur during further development.

Within the same year Oerlikon-Contraves received a second Purchase Contract for four additional, second generation, B-Type Prototypes. These prototypes were to include amongst other things the Siemens MPDR 12 Surveillance Radar with integrated IFF-Interrogator Unit (taken over from Rheinmetall's A-A Tank development). The Tracking Radar Unit was to be improved and include effective permanent echo elimination facilities.

In the meanwhile, the Dutch Quartermaster General was endeavouring to acquire a prototype

* IABG = Industrieanlagen-Betriebsgesellschaft m.b.H.



V contract signed between BWB/consortium
L Leopard chassis approved
EA OK for development
W order Dept. T: autonomous development
A Founding consortium MATADOR
○ Start preparation
● Start development
△ Delivery terms suggested

PF Military statement of work presented
KV Sales contract BWB/OC (2 prototypes)
P Demonstration (target lock-on and tracking)
Z Firing trials Zuoz
■ Start development
▲ Acceptance by BWB
x Start preparations 35 mm PFZ, type B (C)

equipped with Hollandse Signaal Apparaten electronics to be used as a comparative system and included in the 35 mm system trials. This led eventually to a prototype being procured in which the HSA electronics was integrated. To guarantee more coordinated system management of the 30 mm development concept, the "Matador" Joint Working Group was established in 1958, especially for this function.

In order to present the reader with a clear overview, the development schedules for each of the competing systems are graphically illustrated on this page.

It was not only the satisfactory trial results of the 35 mm system, but also the continual delays the Matador development was experiencing in combination with the national economic situation which forced a decision, in favor of one or the other of the systems.

Within the first half of 1970, the selection process was completed. The final decision by the German Minister of Defense fell on June, 25th 1970, the contents of this decision were as follows:

☐ Further development of the 30 mm "Matador" A-A Tank was stopped.
☐ 35 mm Oerlikon A-A Tank development would continue until completion, with the objective of its eventually being introduced into service with the Army. The decision regarding procurement would be taken of a later date. The completed development of the system must include increasing the immunity of the system to electronic-counter-measures (ECM).

□ The Tracking Radar Unit "Marder" from the "Matador" Program would be developed further.

The MATADOR 30 ZLA Anti-Aircraft Tank, the Command/Surveillance Tank and the 35 mm Oerlikon Anti-Aircraft Tank developments are all described in detail in the following chapters of this book.

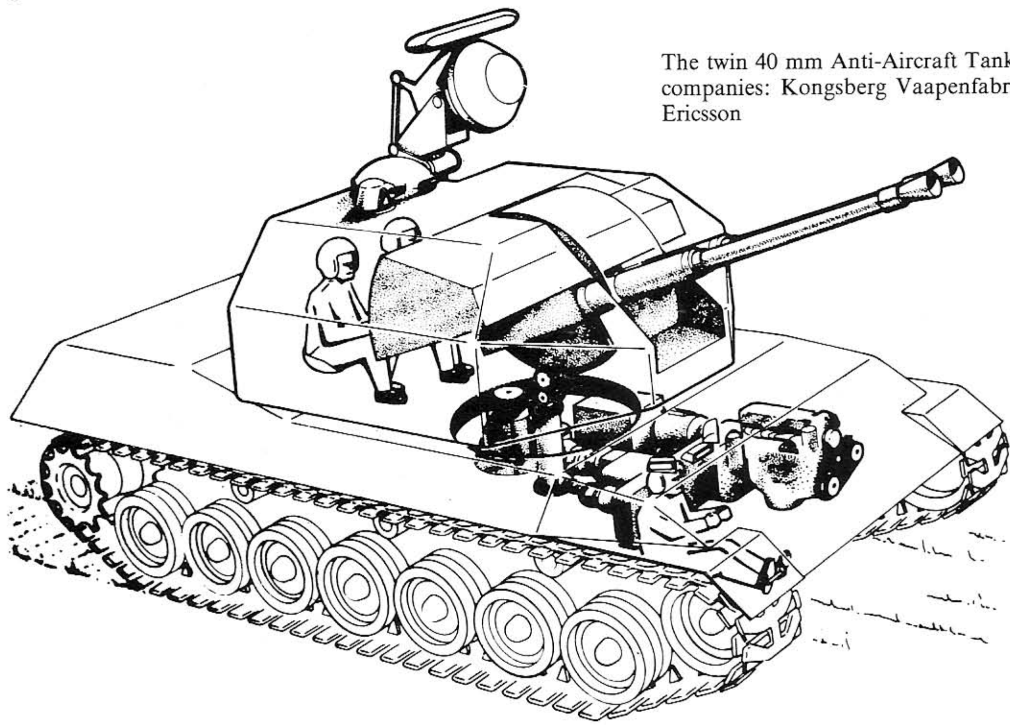
5.5.1 Aktiebolaget Bofors Anti-Aircraft Tank Project (40 mm Twin gun)

At the beginning of 1967, a Scandinavian Industrial Consortium composed of Kongsberg Vaapenfabrikk of Norway, AB Bofors and L.M. Ericsson of Sweden presented for consideration to the German Ministry of Defense, their twin 40 mm gun Anti-Aircraft Turret concept. This turret had been designed to fit on the Leopard MBT chassis. A prototype turret was already available, mounted on the Swedish 40 mm L 62, VEAK 40 Anti-Aircraft Tank Chassis. Adaptation to suit the German chassis had already been investigated by Bofors prior to their submitting their proposal.

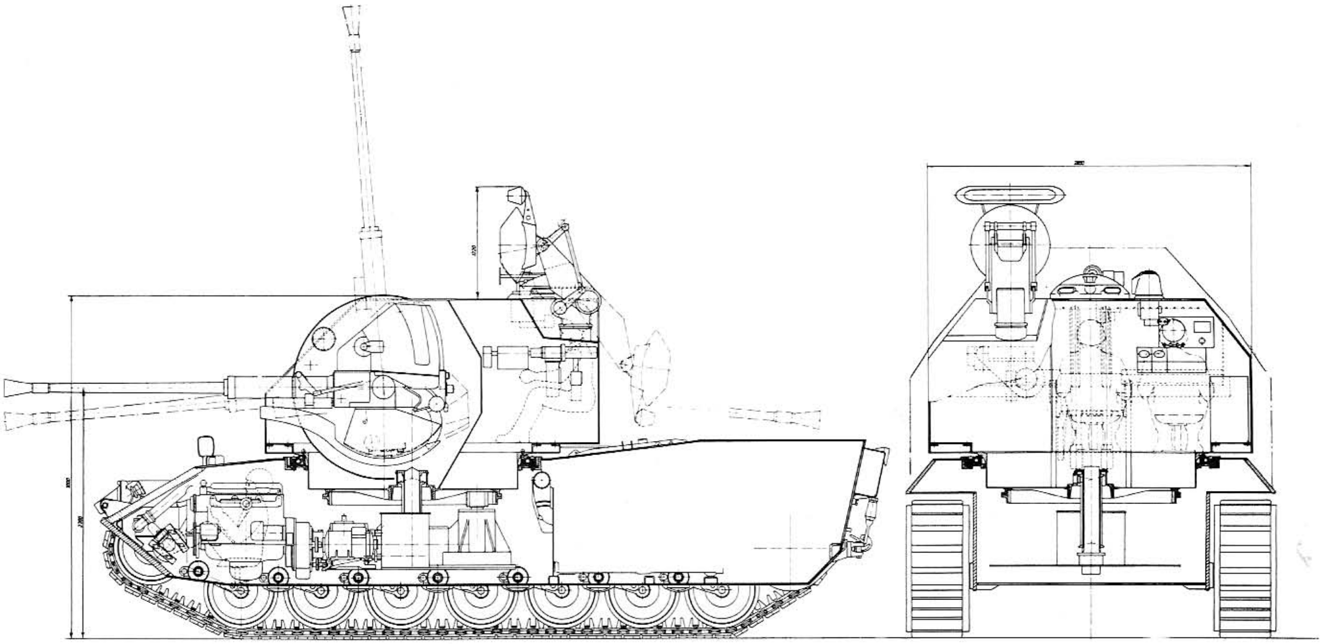
As early as the Summer of 1965, Bofors together with Rheinstahl-Hanomag had investigated the possibilities of mounting an anti-aircraft turret on the chassis of the new armored infantry carrier. Whereby it had been determined that the APC chassis would need considerable reinforcement to facilitate such an installation and still retain its automotive characteristics in regard to mobility.

After Bofors had received authorisation from the Ministry of Defense, they together with Porsche AG, in February 1966, commenced investigations proving that the chassis was suitable for integration with the Bofors turret.

The following modifications and adaptations would be necessary however:
□ Introduction of a lockable form of suspension (blockable shock absorbers)
□ additional fixtures and reinforced turret drive mounts were necessary
□ Main engine cooling, together with air intake and exhaust outlet were in need of modification for parallel operation with an auxiliary power unit for traversing the turret
□ relocation of the electrical equipment.

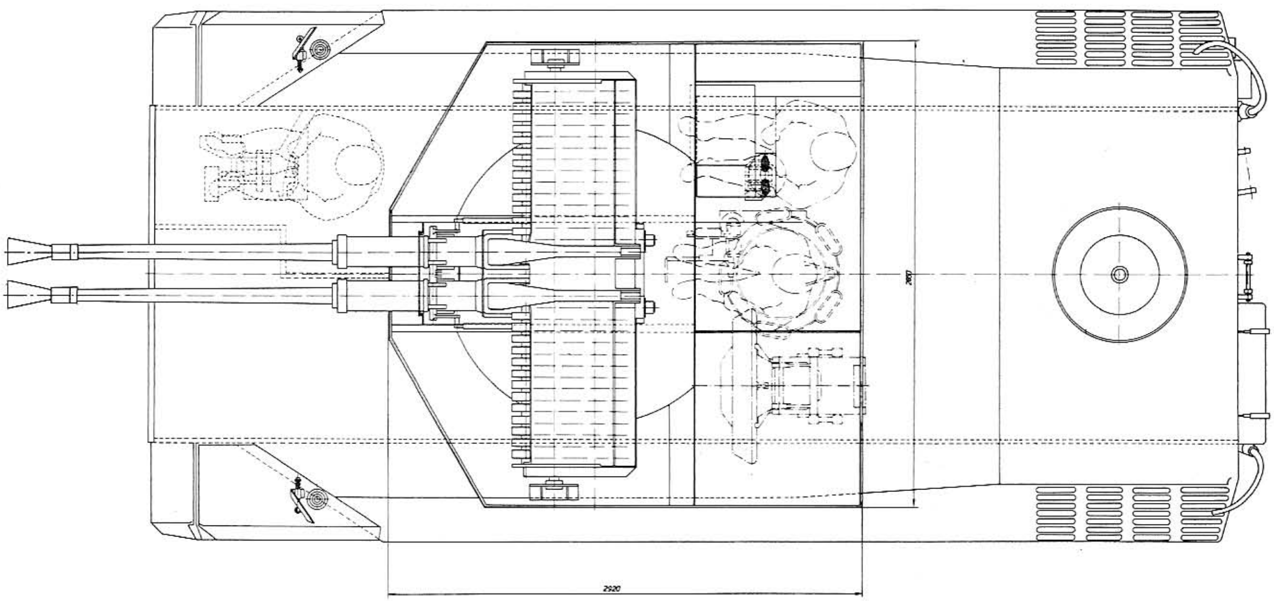


The twin 40 mm Anti-Aircraft Tank Concept proposed by the companies: Kongsberg Vaapenfabrikk, AB Bofors and L. M. Ericsson



Side and Front Cross Sections of the Bofors TEAK 40 × 66 Concept, showing turret details

Plan view of the Bofors Anti-Aircraft Tank Concept



The Radar Unit used in the prototype was a provisional unit. For further development it. was planned to use a Pulse-Doppler Radar Unit which L.M. Ericsson were developing. It was planned to supplement this Radar by installing an infrared Sensor and a Laser Range Finder in order to increase the immunity of the system to electronic-counter-measures (ECM).

As armament it was proposed to use a twin version of the Bofors 40 mm L/70 Machine Cannon, the single version of which was already in service with the German Army.

Servo-technical components of the antenna drives were to a large extent identical with many of those already in service. The majority of the computer electronics were similar to those integrated within the German Navy's Anti-Aircraft Systems.

The Bofors Anti-Aircraft Turret was mounted on a turret ring which was smaller in diameter than that of the Leopard MBT. It was planned to use a Daimler-Benz, OM 352 Diesel Engine as the power source for the auxiliary power aggregates. The fighting compartment was fully NBC protected. Ground targets could be engaged using a telescopic sighting unit. The system was laid out for operation by a three-man crew.
This concept which the Bofors Co. had proposed was rejected by Department RÜ VII 2 of the German Ministry of Defense.

5.5.2 Anti-Aircraft Tank Development, MATADOR 30 ZL (ZLA) (30 mm Twin-cannon) by Rheinmetall

On September 27th, 1965, the German Minister of Defense authorised development of an anti-aircraft tank which was to utilise the chassis of the Leopard Main Battle Tank. The concept selected for further development was based on a joint feasibility study for a twin 30 mm system, also utilising the Leopard chassis which had been carried out by the companies Rheinmetall, Telefunken and Porsche. This study had been authorised under the BWB Contract numbered WM I 4/001/T 109 A702/1 and was started on 8th April, 1965 and continued until of August, 1966, under BWB Contract, BWB WM I 60/01/515/A 702/6 to realise prototype hardware.

It was also decided at this time to incorporate the 30 mm HS831 gun system which had already been developed by the Hispano Suiza Ca. for an armored infantry carrier. The military and technical requirements for the system were established as follows:

- ☐ all-weather day/night capability for both the fire control and surveillance systems
- ☐ radio equipment
- ☐ maximum combat weights
  turret appr. 12,000 kg
  AA Tank complete 42,000 kg
- ☐ Leopard MBT chassis with suitable power supply system
- ☐ machine cannon with the highest possible cadence, effective at slant ranges of up to 3,000 m
- ☐ capable of engaging aerial targets travelling at speeds of up to 400 m/s at altitudes between 2,000 m and tree-top level
- ☐ minimal reaction time (detection, acquisition, identification, target allocation, tracking, interception point calculation, gun-laying and firing)
- ☐ optical aerial and ground target sighting systems
- ☐ unlimited cannon traverse, elevation from –10° to +85°
- ☐ lead angle computer
- ☐ vehicle navigation system
- ☐ crew intercom system
- ☐ ammunition supply both HEI and AP of approx. 1,000 rounds
- ☐ search radar with high clutter suppression using pulse doppler technology with a range of 12 km
- ☐ target tracking radar with a range of 4,000 m
- ☐ IFF – Identification Friend/Foe
- ☐ ECCM – Electronic Counter Counter Measures
- ☐ field telephone connection
- ☐ armored protection against small-arms fire and shell fragments
- ☐ NBC – Nuclear, Biological and Chemical protection
- ☐ deep fording capability
- ☐ electro-magnetic compatibility
- ☐ simple maintainance and repair.

AA-tank prototype Matador mounting twin 30 mm HS 831 cannon. Based upon the chassis of the MBT Leopard

On the 4th of July, 1967, department T VII 2 of the German Ministry of Defense informed the Military Procurement Authority (BWB) that development of the 30 mm AA Tank was to be continued only as an autonomous system. The designation MATADOR 30 ZL (all-weather, low-level, air defense with doppler Radar, twin 30 mm cannon on Leopard chassis) was therefore to be amended to ZLA-A for autonomous. This decision meant that Siemens AG would now join the group of companies participating in the project, as their MPDR 12 surveillance radar was now to be included. On the 28th November, 1967, in agreement with the Procurement Authority – WM 12 – the consortium (ARGE) MATADOR ZLA was established, with BWB approving 11 million DM for financing Project Management. The group was headquartered in Dusseldorf with the financial responsibilities allocated as follows: AEG-Telefunken (40%), Krauss-Maffei (5%), Rheinmetall (30%) and Siemens (25%).

Thereby, AEG-Telefunken were to be responsible for development of the target tracking radar and computer, Krauss-Maffei in co-operation with Porsche for the chassis, inclusive of auxiliary power supply, Rheinmetall for turret and guns. Siemens for surveillance radar and IFF. At this time radar equipment and fire control system of the MATADOR AA Tank were considered to be among the best available.

The effectivness of the weapon system MATADOR was based upon an optimal solution in regard to the various air defense needs likely to occur in combat, such as:

- ☐ determining and displaying the aerial situation within range, free of clutter influences
- ☐ threat evaluation
- ☐ target tracking – fire control
- ☐ ECM resistance
- ☐ target engagement
- ☐ mobility

It is vitally important that for determining the overall aerial situation, particularly with respect to detecting low/very low level targets against terrain background, that permanent echoes are suppressed. To acquire and track such low flying targets, the lower level of the main search lobe lays at ground level, thereby the echoes received by the radar from various surface features and irregularities have a considerably higher reflective energy content than that of an aerial target. These fixed echoes make the detection of aircraft flying at nap-of-the-earth altitudes impossible using normal pulse radar systems.

However, it ist possible to provide interference-free low-level target acqisition by utilising the fact that target echoes reflected from a moving target differ in frequency to those from surrounding ob-

Prototype Matador A-A Tank with open and closed cartridge case ejection hatches on each side.

Detailed view of the cartridge case ejection hatch.

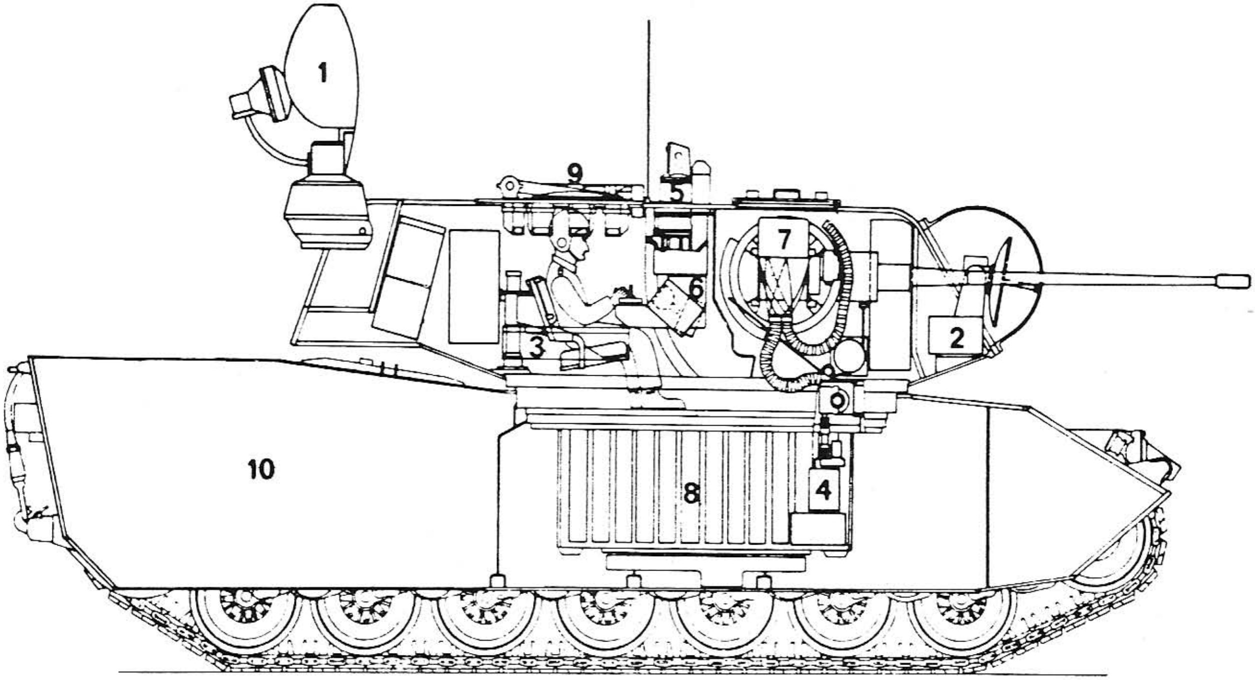
Turret at the 2 o'clock position with search radar antenna lowered.

Prototype Matador A-A Tank with guns at maximum elevation.

Prototype PT 301 Matador with steel turret.

jects because of the targets speed in relation to the radar unit. This doppler effect can therefore be incorporated into a radar system and used to discriminate interference caused by these permanent echoes. Target ranging, however, still remains limited, this drawback can be overcome by coupling a pulse radar with a doppler radar. Such pulse doppler radars can be successfully applied to determine both the range and radial speeds of aerial targets and are ideally suited for such applications.

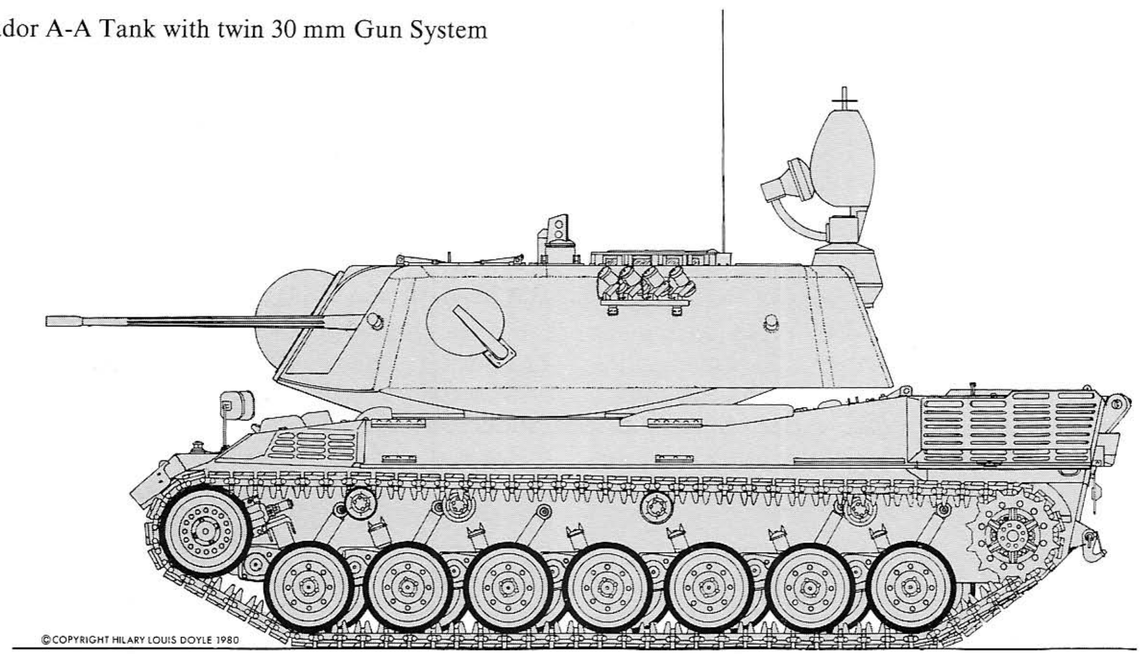
Basically the MATADOR AA Tank offered two possibilities for determining and displaying the air space situation: firstly by using the search radar or alternatively via the fire control radar tracker. The MATADOR AA Tank was equipped with a Siemens search radar MPDR 12 which had a range of 12 km and could be used to determine the status of flying objects within its respective range and altitude. The search radar antenna was hinged at the rear of the turret, the tracking radar unit was mounted at the front face of the turret under a protective radome. The status of the surrounding air space situation determined by the search radar was displayed to the turret crew via a PPI display. In case of search radar failure, the air space situation could alternatively be determined by using



Sectional View of the Matador A-A Tank

1 Search Radar (Siemens)
2 Tracking Radar (AEG-Telefunken)
3 Main Computer (AEG-Telefunken)
4 Back-up Computer (Rheinmetall)
5 Periscopes (Rheinmetall)
6 Operator Console
7 Weapon System (Rheinmetall)
8 Ammunition Bunkers
9 Turret with Hatches (Rheinmetall)
10 Chassis (Krauss-Maffei/Porsche)

Matador A-A Tank with twin 30 mm Gun System



the tracking radar to scan on a line-by-line system selected sectors of the surrounding air space. By additionally traversing the turret complete 360° scans were also possible.

Both threat evaluation and target selection were determinable in the MATADOR system by using the target co-ordinates supplied by the search radar and clearly shown on the aerial status display.

By utilising the afterglow characteristics of the target blip on the PPI display it was possible to determine the target's direction and when it had entered within effective engagement range of the guns. A target evaluated as a high-priority threat could be designated as such on the radar display by placing the appropriate marker around it. After which the target was automatically transferred to the fire control unit.

Target tracking and fire control included target acquisition by the tracking unit (tracking radar or periscopes), calculating both hit and crossing point ranges and gun laying lead angles. These procedures assume particular importance when applied to the provision of effective, low-level air defense. Therefore, the Matador weapon system was equipped with:

- ☐ the pulse doppler, fire control system from AEG Telefunken combined with a digital programmable main computer (quadratic flight-path extrapolation) to ensure highly accurate target tracking and precise gun laying, particulary for targets flying long curving courses.
- ☐ Panoramic target telescopes which could be coupled at will with either the main computer or the electro-mechanical analogue back-up computer for determining gunnery lead angles and controlling the gun laying drives.

In accommodating both the tactical and equipment configurational requirements,target tracking facilities which enabled a number of selectable modes-of-operation became available made possible by redundancy of radar, computer or optronics. The system's main mode-of-operation was established as that where the radar tracker and digital main computer were combined with each other. Of major importance with this mode was the fully automated combined operation of the search radar and fire control radar systems. Such an automatic application was only possible due to both radars being pulse doppler systems which facilitated target evaluation via the display being free of interference caused by permanent echoes.

For fire control it was sufficient to place a target designator marker around a target evaluated as being a threat on the radar screen CCPD, after which the mere pressing of a button initiated fully automatic vectoring and continuous tracking of the "marked" target. Immediately more precise target flight path extrapolation data had been accumulated. The computer ran comparison tests with its stored ballistic data programs and was then able to pin point the target interception point continually renewing these data in accordance with the target's movement.
The moment this "interception point" came within effevtive engagement range of the guns, the gun safety locks automatically released. During target tracking in this mode-of-operation it was possible to pre-select a second target. After completing engagement of the first target selected the tracking radar could be automatically brought to bear on the pre-selected second target by merely activating a switch.
Besides the lead-angle target data supplied from the tracker radar fire control, further corrective data inputs were manually inserted for evaluation such as atmospheric pressure, wind direction and speed. Furthermore the varying muzzle velocity data was also included. The gun elevations were also corrected continually to compensate for any canting or vibrating of the vehicle, the vehicle navigational unit FNA8 was specially developed with this objective in mind.

In the second mode-of-operation, acquisition is carried out using the periscope whereby the turret simultaneously slewed to face the target. Target range and radial speed were whenever possible determined using the tracking radar if this, however, was not possible estimated valves were used. Gun lead angles and elevations in the secondary mode-of-operation could be determined by means of the digital main computer or alternatively the electro-mechanical analogue back-up computer.

The Matador was extremely well armed for its task with twin 30 mm automatic machine cannon. These weapons being ideally suited to their low-level air defense role due to their high firing cadence, minimal ballistic dispersal rate, operational economy and immediate availability.

Calibre, fuse and shell of the 30 mm round of ammunition were so well matched to each other that a "hit" irrespective of its angle-of-impact resulted in such a devastating combination of fragmentation, blast and incendiary effects that an extremely high kill probability was assured.

Electrical signals distributed depending on the selected mode-of-operation via either the main or back-up computer served to control the hydraulically assisted mechanical drives used for traversing the turret or elevating the guns.

Gun laying was fully automatic in normal cases, a manual emergency mode was also available via an electrically operated joy-stick on the console.

Both gun compartments on each side of the turret were equipped with cartridge cases ejectors on the outer side plates. These compartments were totally sealed-off from the turret crew fighting compartment by steel bulkheads, thereby preventing any possible danger to the crew from ammunition fumes when firing.

The large ammunition supply carried by the Matador totalled 1000 rounds in all, enabling a maximum number of combat engagements to be fought with the same high kill probability. In order to accelerate re-loading, ammunition was supplied ready belted and packed in ammunition boxes. These boxes could then be quickly stowed in the turret well and introduced into their respective feed chutes. Additionally, the guns were fitted with secondary ammunition feed chutes enabling a second type of ammunition to be selected. This alternative ammunition was again supplied belted and boxed, the boxes being stowed directly below their respective feed chutes.

Other essential sub-assemblies of the weapon system such as the search radar, IFF equipment, tracking radar unit, computers, gun system, ammunition and operational controls were all installed within an enclosed armored steel turret, matched to fit the hull of the Leopard MBT. Both commander and gunner were provided with hatches in the roof of the turret, both of which could be opened and closed either electrically or manually. Stowage and layout of the various equipments within the turret were ideally resolved and took fully into account the major parameters imposed by the all important human engineering design aspects. The additional installation of an air conditioning unit served to enable the crew to withstand extended periods of time within the vehicle even when all the hatches were fully battened down, without any detrimental effects to their combat performance. All of the various control elements and indicators were optimally sited with regards to their ergonomic and visual requirements. This was very important in assisting the crew to react very quickly during the decisive phases of an engagement, and helped to eliminate possible incorrect operation occurring. Contrary to the military deep fording requirement applicable for main battle tanks the Matador was only capable of deep wading operations to depths no greater than turret roof level. The electrical power requirements necessary for operation of the various equipments within the turret were achieved by means of an auxiliary diesel engine. This same engine served simultaneously for driving the hydraulically assisted mechanical turret traverse drives and was installed in the front left side of the hull. To protect the driver when driving the vehicle with his hatch open, a protective grill was fitted which ensured that no head injuries could occur during turret traversing or from ejected cartridge cases and belt links during firing.

On July 3rd, 1968, Krauss-Maffei received a contract from Dept. KB II 1 of the German Defense Procurement Agency (BWB) to convert and adapt three Leopard "0" series chassis to Anti-Aircraft Tank chassis. These new chassis were designated the numbers PT 301, PT 302 and PT 303 and the Leopard chassis numbered M-0-22, J-0-19 and J-0-37 were made available for conversion. Krauss-Maffei modified these chassis to accept their new AA turrets. Static bench testing of the proposed

auxiliary power supply took place in Munich, chassis works trials took place at the Porsche Co's premises in Weissach near Stuttgart. Weissach was also the location where the final acceptance trials were undertaken by Dept. KG of the Procurement Authority. At the end of November 1969, the PT 301 chassis, complete with a Rheinmetall turret, underwent trials at Unterluess. Prototype PT 302 complete with fire control and radars underwent trials at AEG-Telefunken in Ulm-Ehrbach. Chassis PT 303 complete with auxiliary power supply unit remained in possession of Porsche in Weissach for comprehensive trials of both chassis and power supply systems. This auxiliary power supply unit was driven by a standard, commercial OM 314 Daimler Benz Diesel engine, it was due to continual break-downs of this engine that the development program suffered some considerable delay. Besides the power supply unit, both the Bendix tree phase generator (AEG-Telefunken) and the turret drive (Rheinmetall/Galileo) were also major sources of concern. During firing trials by Rheinmetall in Unterluess repeated failure of the weapon system occurred.

For operation of the Matador A-A Tank, the power requirement originally established for the system, 10 kVA proved to be inadequate. Generator output was therefore increased to 20 kVA which in turn led to occasional system overloading occurring.

Two turret weight simulators were procured for use during trials.

In order to stress the urgency of the A-A Tank development program, the Ministry of Defense, Dept. T VII 2, presented the Defense Procurement Authority (BWB) with a document containing the fixed priorities which had been established for the new system. These priorities were as follows:

Presently, mobile units of the army are inadequately equipped with effective means of air defense against low-level attack aircraft. Air defense weaponry currently in service is not able to provide effective protection against such threats and will be taken out of service in the near future. In order to provide improved air defense facilities for both these mobile units and other strategically important military installations in future years the A-A Tanks are being developed. The first prototype vehicles are therefore required to be delivered to the responsible authorities at the end of 1968 to facilitate commencing trials early in 1969.

Therefore, in full agreement with the Armies General Staff it ist requested that trials of the A-A Tank be allocated a Priority I classification. Due to various technical problems ARGE Matador were unable to meet these requests.

In August 1968, in order to establish program development on a broader basis, the Procurement Agency KB (BWB) ordered three new mild steel chassis from Krauss-Maffei (prototypes PT 304, 305, 306). These new chassis were generally based upon that of the original specification as it stood, prior to the inclusion of the autonomous operational requirement. Considerable revisions to this original specification were made by ARGE. These revisions lead to considerable modifications when compared with the original concept. Due to the intensive application of standard components from the MBT Leopard 1, Mk 4 production, improvement of the chassis particularly with respect to it's armored protection and the stowage of A-A Tank oriented sub-units (auxiliary power supply, turret drive etc.) were necessary.

A combined economy and effectivity study carried out by the Operations and Research Departments of the IABG Co., proved that neither the 30 mm nor 35 mm A-A Tank programs offered any distinct advantages over the other. In spite of the very modern concept of the MARDER fire control system, low development funding and earlier availability of the 35 mm Oerlikon system proved to be decisive factors leading to it's being selected.

One June 26th, 1970 the Ministry of Defense, Dept. T VII 2 issued the following policy statement:
On the basis of the recently submitted system evaluations further development of the 30 mm A-A Tank weapon system will be discontinued, however, the fire control system development part of the program will be continued.

Development of the 35 mm Oerlikon A-A system will carry on until completion with the final objective being its entry into service with the Army. A decision regarding any initial procurement and the quantities involved will be made at a future date. The anticipated development will include increasing the resistance of the system to electronic counter measures.
This statement led to the contract for the prototypes 304, 305 and 306 being cancelled on June 30th, 1970, by the Defense Procurement Authority. However, the PT 304 prototype chassis was completed for carrying the 35 mm system and thereafter designated as PT 358.

The MATADOR 30 ZLA consortium ceased work in June 1970 and was dissolved on January 1st, 1971. Individual elements from the cancelled program (Siemens Surveillance Radar) were absorbed into the 35 mm A-A Tank development, others passed into differing areas of air defense. For development of the 30 mm A-A system 185 million Deutsch-marks had been allocated and up until the time of its cancellation, approximately 100 million had been spent.

5.5.2.1 Anti-Aircraft Command/Surveillance Tank

The tactical application for the MATADOR Low Level Air Defense System was two-fold; firstly to provide air defense for armored units in the forward battle area, secondly to provide defense facilities for strategically important installations and equipment in rearward areas which were also likely to be priority targets for low level attack by enemy aircraft. It was in order to accomplish both these requirements that the division of air defense into two differing roles was envisaged as follows:

- an air space surveillance command/control tank system = TUPA (Tieffflieger-Überwachungspanzer)
- and the combat engagement tank system (Anti-Aircraft Tank) = TAPA (Tieffflieger-Abwehrpanzer).

The Army General staff did not believe at this time that a radar antenna of sufficient dimensions could be mounted on a vehicle without making it too conspicuous.

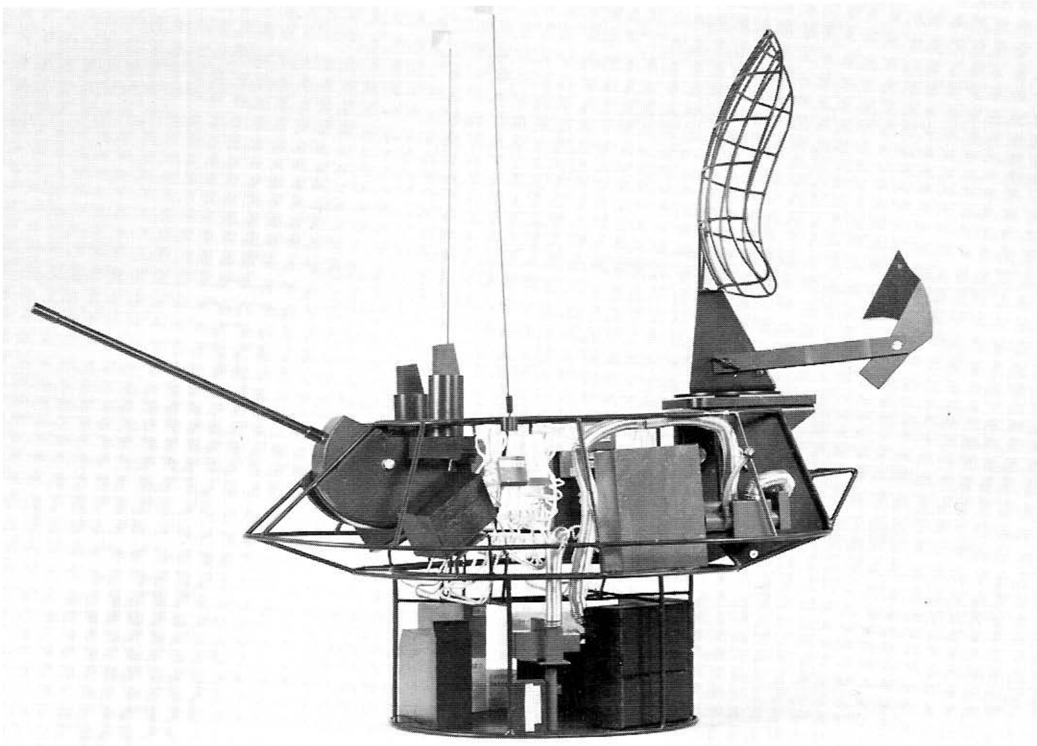
It was considered that in order to provide maximum tactical efficiency and highest level of aerial protection of a given area, small groups (3 or 4) of A-A Tanks led by an A-A Command Surveillance Tank be combined to provide co-operative units.

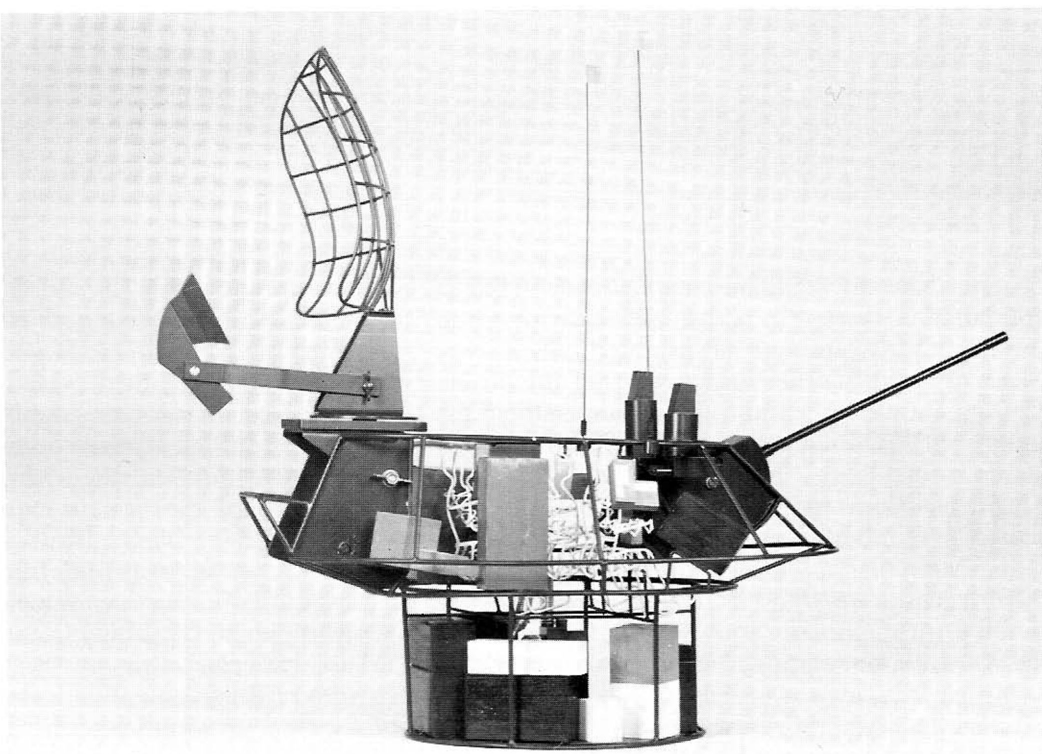
As the system carrier for both the A-A Command/Surveillance vehicle and the A-A Tank it was planned to use a modified version of the Leopard MBT. The chassis modification requirements for both turrets were extremely compatible with each other and facilitated a high level of vehicle interchangeability. The armor steel turret of the Command/Surveillance tank was composed of two major sections, the armored steel, turret shell and the turret well. It was planned to arm the vehicle with a 20 mm Rheinmetall Rh 202 machine cannon installed in the turret front. This weapon had a muzzle velocity of 1,050 m/s, a rate of fire of 1,000 rounds/min. and an effective range of 1,200 to 1,500 meters. A third turret crew member was planned to serve as radio operator. The turret was very similar to that of the A-A 30 ZL concept.

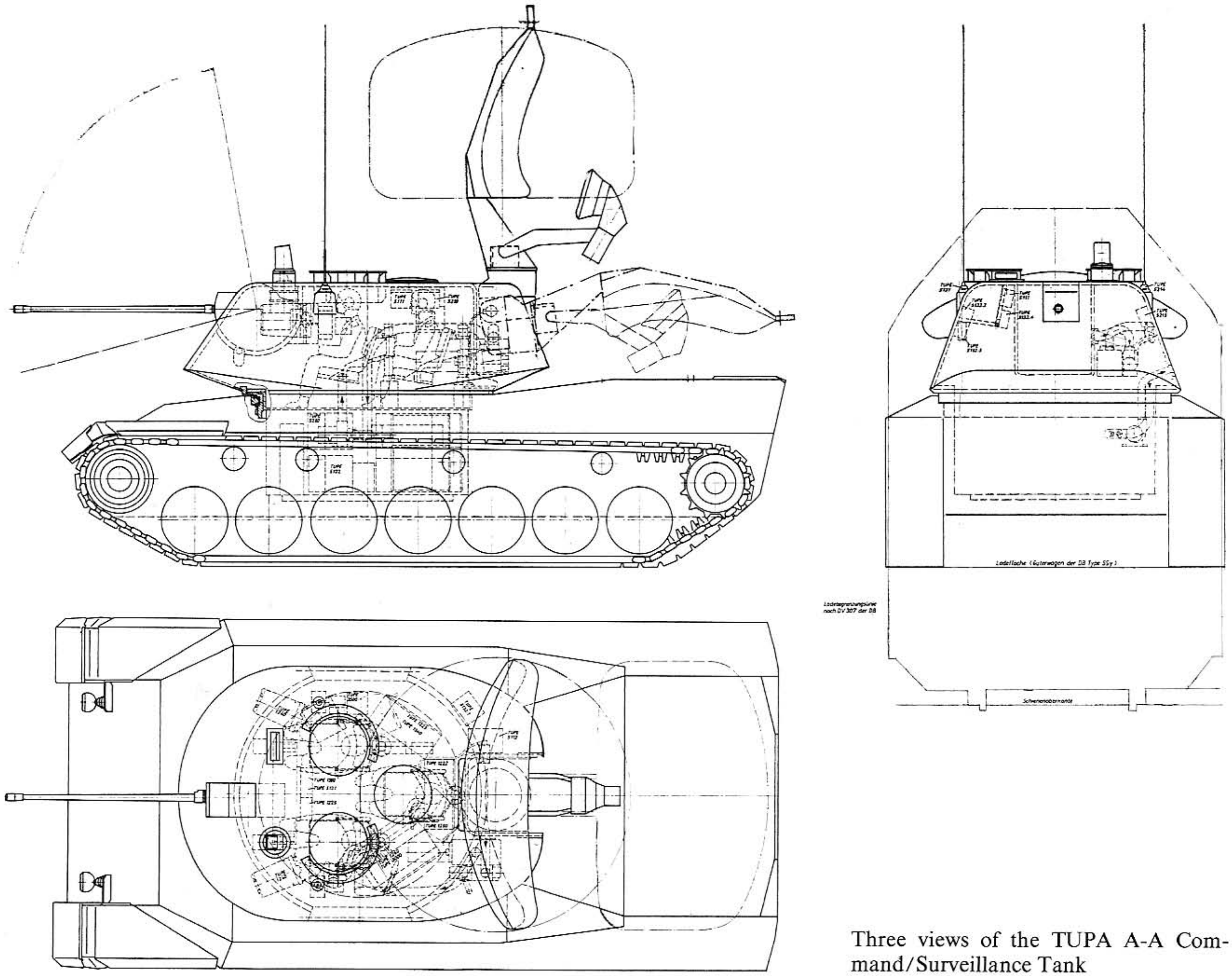
Turret armor thickness was approximately 30 mm with the turret traverse drive system being similar to that used in the A-A 30 ZL vehicle and incorporating many of the same electro-hydraulic drive aggregates. In order to comply with the all-weather and early target acquisition requirements (to a 2,000 m ceiling), the command/surveillance vehicle was to be equipped with a Siemens L-Band MPDR 20 search radar. Application of pulse doppler radar technology being selected to provide the highest probability for target detection irrespective of interference by high permanent echo sources from the surrounding terrain. Radar range was to be a 20 km radius. Target detection was to include the capability to determine the range and azimuth of all moving targets within search radar range.

This target data was to be displayed via the PPI (Plan Position Indicator) of the display console in the command/surveillance tank's turret. Simultaneously this data was processed by the digital computer, converted into reference co-ordinates and shown on the UTM (Universal Transverse Mercator) Grid. Thereafter this information was

Wooden Turret
Mock-up of the
TUPA A-A
Command/Sur-
veillance Tank







Three views of the TUPA A-A Command/Surveillance Tank

processed by the command/surveillance vehicle's computer, converted by a data converter unit into transmittable form and transmitted via a type SEM 25 radio to other vehicles within the group. Continual up-dating and transmission enabled the other vehicles to maintan contact with the combat status around them.

The consortium (ARGE) MATADOR ZL presented a number of solutions for an AA Command/Surveillance Tank to the Federal Procurement Agency (BWB) on March 22, 1968. They selected a turret configuration similar to the one of the AA-tank, but equipped with only one weapon. Logistical reasons suggested the use of a 30 mm cannon. The concept AA Command/Surveillance Tank was to be continued as suggested.

Other study concepts showed the A-A Command/Surveillance tank armed with 20 mm twin cannon, whereby the Rheinmetall Rh 202 was the weapon preferred. Investigations with the A-A 30 ZLA tank showed that by omitting the Marder fire control system sufficient space became available within the turret for housing a three man crew and stowing all of the various equipments the A-A Command/Surveillance Tank required. Furthermore, this concept was preferred in many quarters as the additional cost per vehicle for the 70 to 100 vehicles planned was only in the region of 100,000 DM per vehicle.

However, in agreement with department WM I 2 of the Procurement Authority it was decided to proceed with an asymmetrically mounted single

30 mm cannon, although the final decision regarding caliber was left open, pending further decision at a later date. This mono-cannon concept provided sufficient space for installing an IFF unit.

A contract dated August 7th, 1968, between Department KG of the Procurement Authority (BWB) and Krauss-Maffei made provision for converting two main battle tank-0-series chassis (L-0-8- and J-0-29) to carriers for the Surveillance Radar. It was also planned to install a power supply unit driven by the Daimler Benz OM 314 auxiliary Diesel engine in the TUPA vehicle chassis.

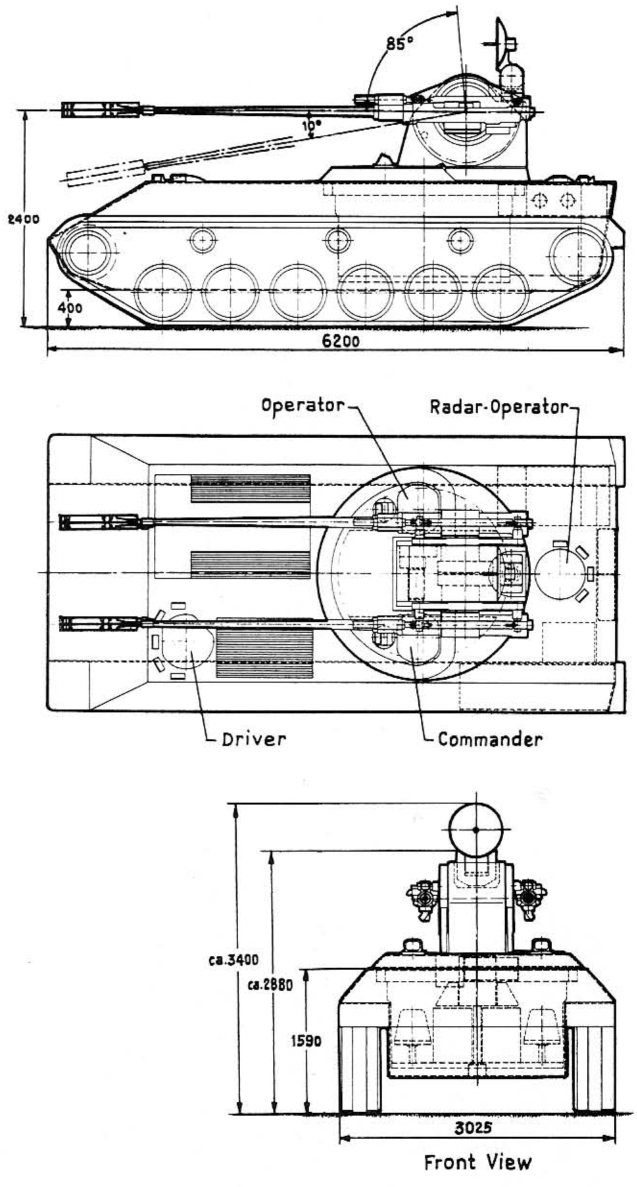
On August 30, 1968, the entire project AA-Command/Surveillance-Tank was cancelled. Components, already produced were to be used for the prototypes 304 to 306.

5.5.3 Anti-aircraft tank development (35 mm twin cannon) by Oerlikon-Contraves

With the objective of carrying out an intensive basic study to develop an effective mobile air defense gun system, the three Zurich based Swiss companies Machine Tools Oerlikon Bührle, Contraves AG and Albis AG established an industrial consortium in 1963. The main aims of this consortium were the realisation of an anti-aircraft tank system fully able to satisfy the following tactical requirements:

- ☐ fully autonomous combat capability complete with IFF recognition facilities
- ☐ all-weather combat ability
- ☐ maximum effective engagement range
- ☐ fast re-acting
- ☐ extensive immunity to electronic counter measures
- ☐ fully tracked
- ☐ effectively armored against small arms fire and fragments
- ☐ NBC protected
- ☐ carrying maximum quantities of ready-to-fire ammunition against both aerial and ground targets – with fast acting ammunition selection facilities
- ☐ simple to operate, maintain and repair
- ☐ high cost effectiveness.

The decision to propose the twin 35 mm machine cannon concept for consideration was initially made by Oerlikon in January 1958. However, due



Oerlikon-Contraves proposal for installing a twin 35 mm system on the MOWAG Armored Infantry Combat Vehicle Chassis.

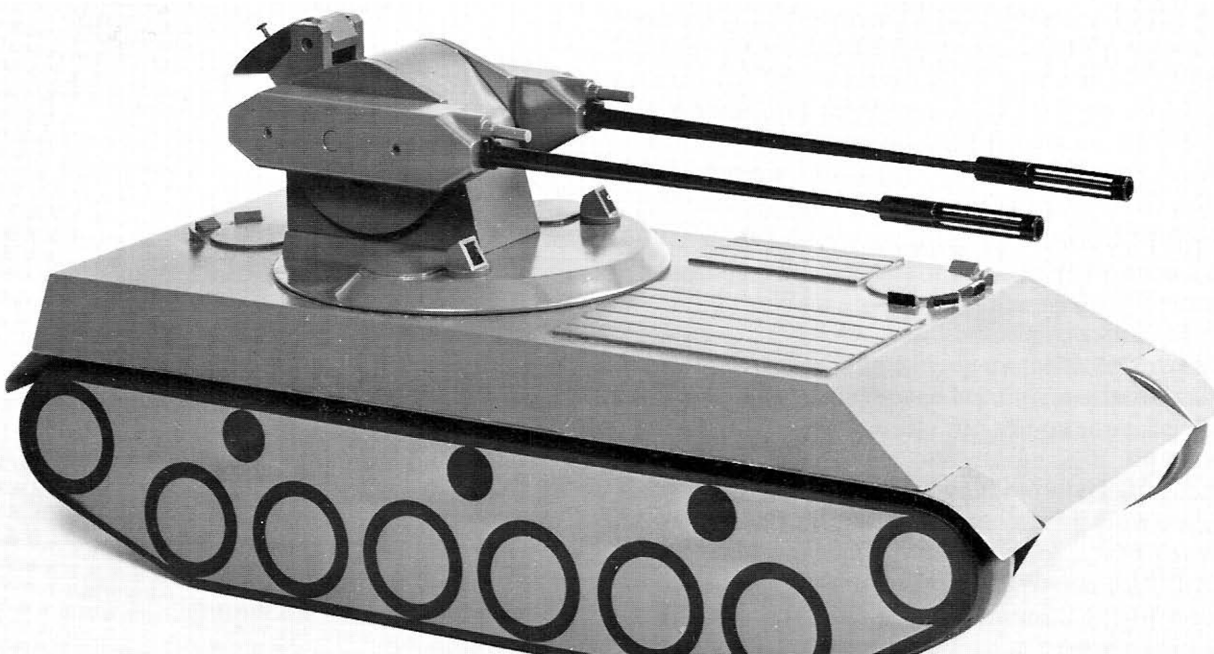
to the high weight of the turret (10.7 tonnes) this concept was not continued further since it was to mounted on the APC chassis.*

In April 1959, Oerlikon resurrected the twin 35 mm A-A Tank project, in March and June 1962, further improvements and modifications were incorporated into the system concept. Unfortunately, on August 2nd, 1962, Department FüH II 5 of the German Ministry of Defense totally rejected the 35 mm concept being proposed and requested that 30 mm caliber weapons be substituted. This request eventually led to a ministerial decision on May 13th, 1963, which categorically rejected any chance of the 35 mm weapons being introduced into service with the German Armed Forces. Oerlikon's 35 mm proposal founded upon results obtained from extensive investigations and trials clearly illustrated that the 35 mm caliber was however pre-destined for eventual selection based upon the tactical requirements which had been established.

The 35 mm type 353 machine cannon had to be redesigned to facilitate faster selection of an alter-

* Integration studies for the following vehicles: MOWAG Armored Infantry Combat Vehicle, HANOMAG Armored Infantry Combat Vehicle, HAEGGLUNDS Light Battle Tank (Type 3 PFZ).

Wooden model of the MOWAG-SPz with 35 mm Weapon System. The Type 3 PFZ upper left with Surveillance Radar, below without Radar.



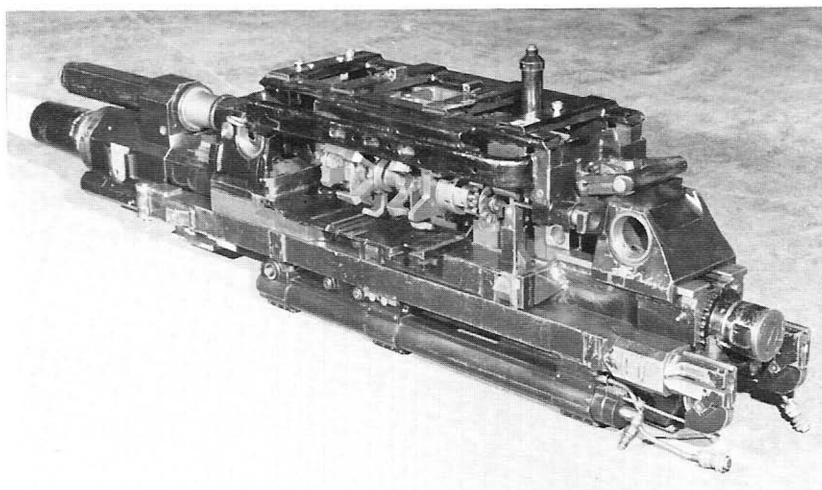
native type of ammunition as specified in the requirements. The 353 L/90 A-A cannon is a positively locking, gas operated weapon capable of firing either individual rounds or bursts of fire. Whereby the original type 353 cannon was loaded with clips of ammunition, for its 35 mm A-A tank application an ammunition feed system using steel link, belted rounds was developed.

5.5.3.1 Anti-Aircraft Tank Prototypes: Works Prototype, 5 PFZ-A, 5 PFZ-B

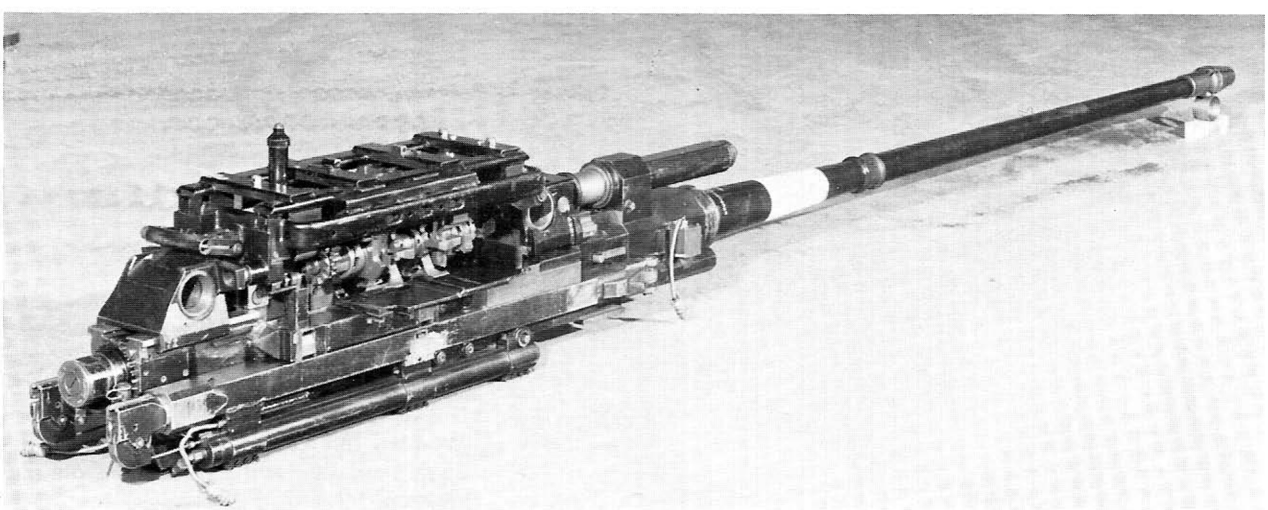
In 1966, the Swiss consortium commenced development and construction of the 35 mm Anti-Aircraft Tank. On June 23rd, 1966, Department WM I 1 of the German Procurement Agency signed a contract with Oerlikon-Contraves for the delivery of two A-A Tank prototypes for a purchase price of 8.8 million DM.

In September 1968, Department KB II 1 completed a contract with Krauss-Maffei AG for converting and delivering two 0-series Leopard MBT chassis to Oerlikon-Contraves. Oerlikon-Contraves were then to install their twin 35 mm weapon systems on these chassis. These completed vehicles were allocated the type designation 5-PFZ-A. The first converted MBT chassis, numbered L-0-33,

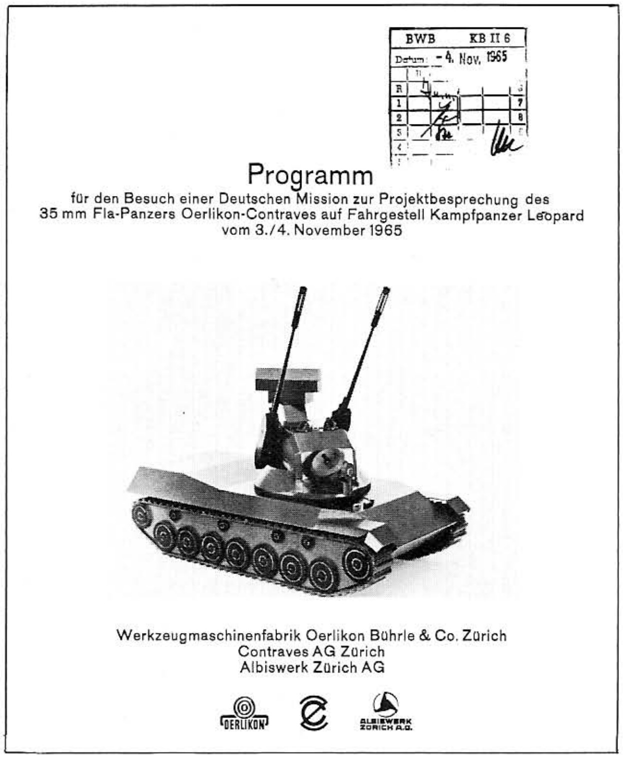
The 35 mm Machine Cannon Housing complete with Barrel Mount, Breech Mechanism, Trunnion Bearing and Ammunition Feed Sprocket.



The original version of the Oerlikon Type 355 MK Machine Cannon.



was quickly made available and delivered on September 19th, 1967, with the second chassis L-0-14 being handed over by Krauss-Maffei to Oerlikon-Contraves on December 11th, 1967.


BWB KB II 6
Datum: -4. Nov. 1965

Programm

für den Besuch einer Deutschen Mission zur Projektbesprechung des 35 mm Fla-Panzers Oerlikon-Contraves auf Fahrgestell Kampfpanzer Leopard vom 3./4. November 1965

Werkzeugmaschinenfabrik Oerlikon Bührle & Co. Zürich
Contraves AG Zürich
Albiswerk Zürich AG

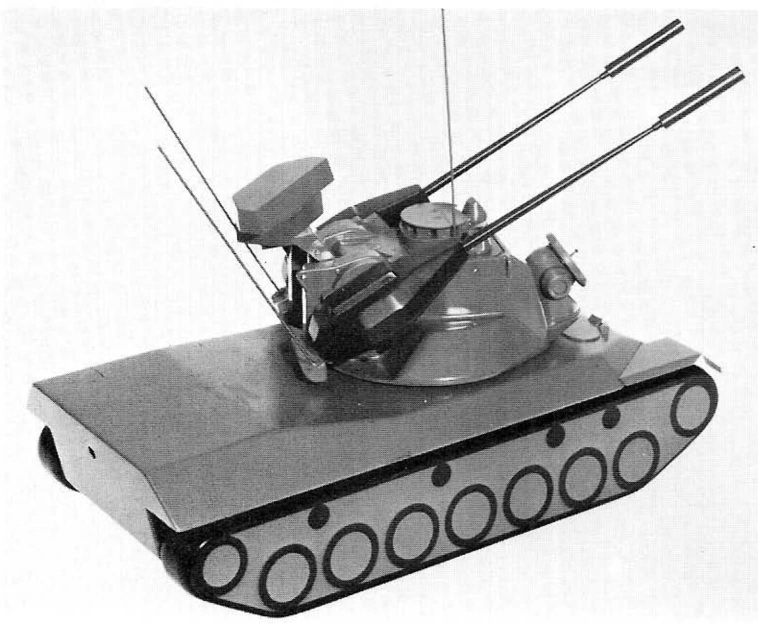
OERLIKON

ALBISWERK ZÜRICH A.G.

In 1968, Oerlikon-Contraves asked the German Procurement Agency (BWB) to borrow a Leopard chassis, to enable them to undertake a series of works trials which they wished carry out funded by themselves. The chassis for these trials complete with power supply system (M-0-15 chassis of the 0- series) was handed-over to Oerlikon-Contraves by Krauss-Maffei on April 9th, 1968. Whereafter, this chassis was fitted with a turret, equipped with Albis Tracking Radar Unit and Contraves Surveillance Radar. At this time no final decision had been reached regarding the type of construction to be used for manufacturing the series production turret, two forms of construction being considered, the first a cast/welded plate combination the second an all welded design.

For both works- and "A" series prototypes, cast turret housings were manufactured by Georg Fischer Co, of Schaffhausen.

On June 25th, 1968, in Zurich, Oerlikon-Contraves presented the first 35 mm Anti-Aircraft tank prototype to demonstrate both gun-laying and aerial target tracking. Initial outdoor firing trials using live ammunition and towed gunnery drogues took place in Zuorz (Switzerland) during November 1968. These trials successfully demon-



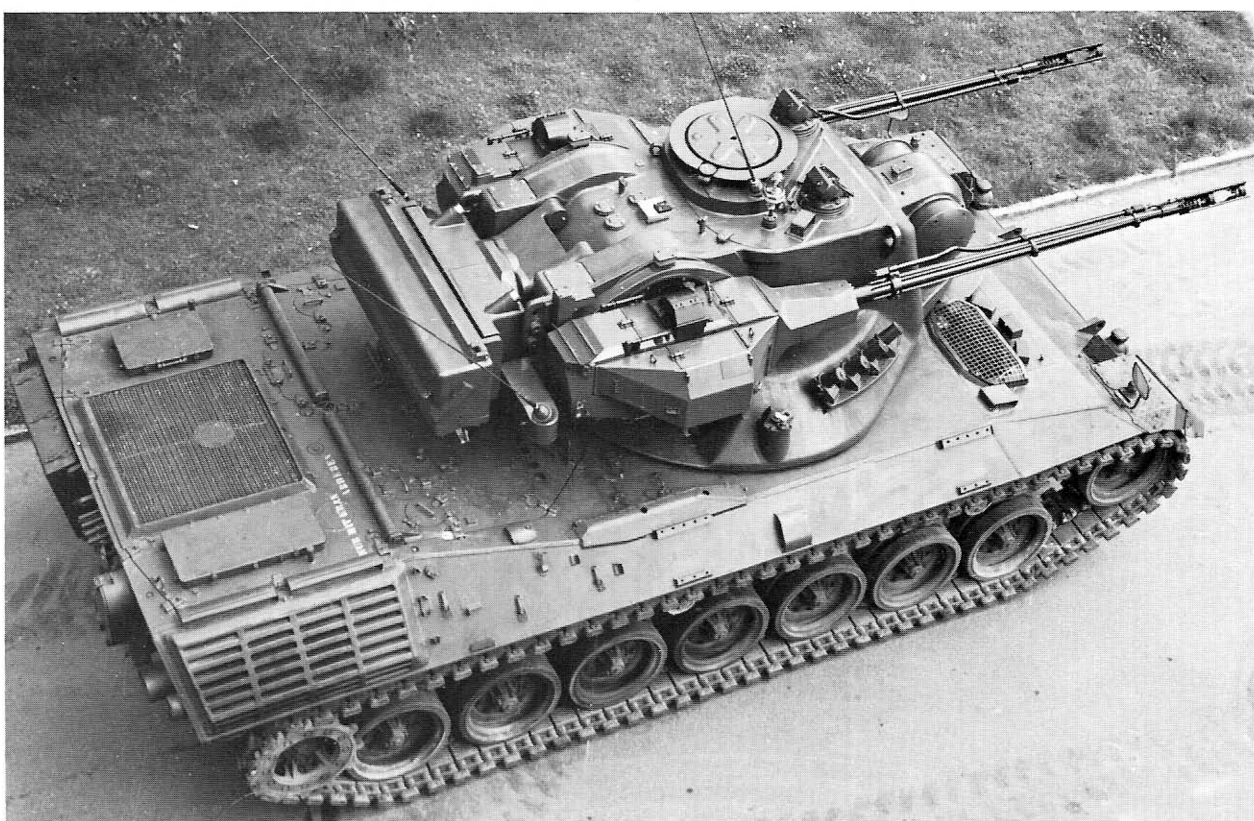
Wooden model of the works prototype 35 mm weapon system mounted on the Leopard MBT Chassis.

Works prototype during assembly by Oerlikon-Contraves. Shown with and without the weapons.

Side view of the Oerlikon works prototype.

Works prototype with CW-Doppler Surveillance Radar from Contraves-Italy and a Tracking Radar Unit from Siemens-Albis.

View of the A-A Tank from above showing the original turret shape and small turret hatch.



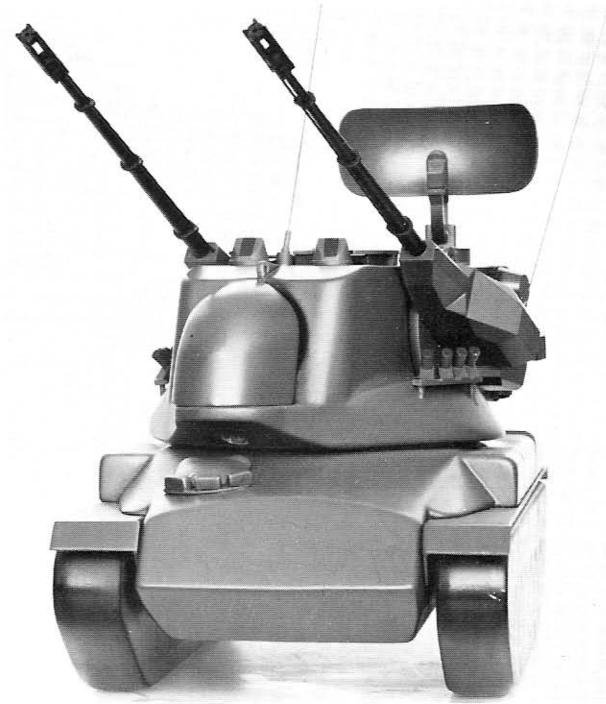
strated the functional ability of the complete system, above all else however, provided a convincing demonstration of the inherent precision of the newly developed fire control and weapon system.
By fully utilising the extensive experience which had been acquired during works-prototype trials, Oerlikon-Contraves were able to deliver the first of the 5 PFZ-A prototypes purchased to the German Armed Forces proving ground No. 91 by the end of 1968. Furthermore, the German Military Requirements which had been stipulated in the system standard specification of 1966 were satisfactorially resolved. Delivery and acceptance of the second prototype followed in Spring of 1969.

Trials with both prototypes were conducted during the remainder of 1969 and were carried out in three phases. Testing of the fire control system with particular emphasis to the radar equipment. Weapon system tests and gunnery trials using both towed drogues and drones.

The fire control system particularly with respect to its precision, tracking accuracy, range and component reliability completely satisfied the military requirements. Similar such positive results were also achieved by the weapon system, its functioning having been subject to particularly stringent trials in extremes of environmental and operational conditions. Whereby, the basic concept of externally mounted weapons, automatic ammunition feed and loading proved to be extremely effective solutions.

It was particularly noteworthy for such a new, unique and complex weapon system that it should function so well from the very beginning, the extremely good firing trial results achieved from the very start of trials at the NATO Anti-Aircraft Ranges at Todendorf (on the Baltic Sea Coast) were highly commendable. The high standard of continual system readiness during the whole duration of the trials in spite of the telling demands particularly with regard to the fire control system were also quite remarkable.

However, the following points were established:
☐ the Albis tracking radar could not meet the demands made upon it, particularly during aerial attack at nap-of-the earth altitudes



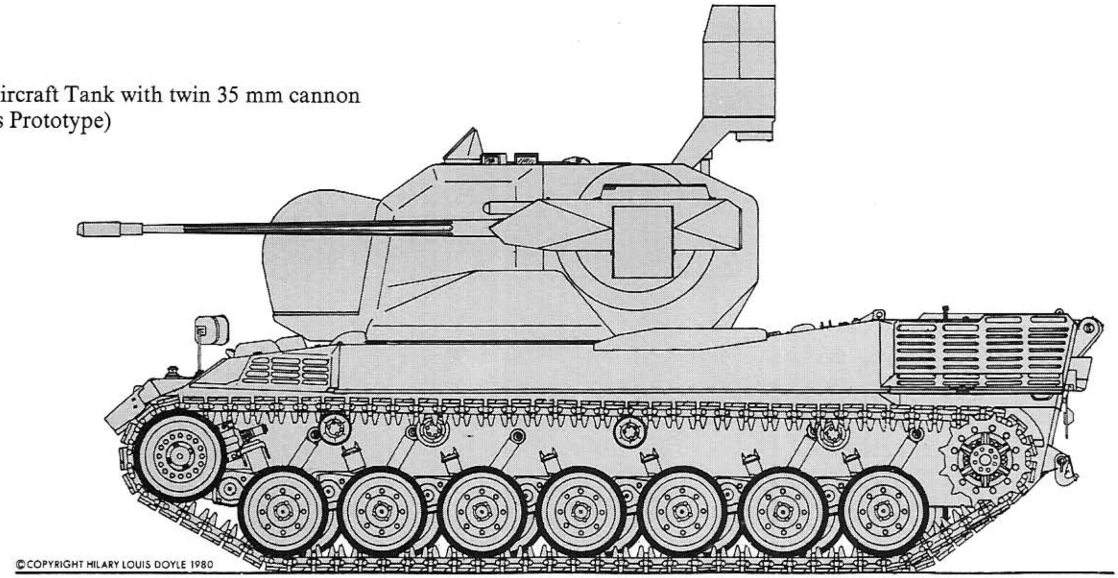
Model of a Clear-Weather variation of the A-A Tank for Switzerland (1970).

☐ both commander and gunner required additional automated assistance to relieve them of some of the burden of their assigned tasks
☐ optics and electrics were good
☐ in all each system fired 5,750 rounds during trials.

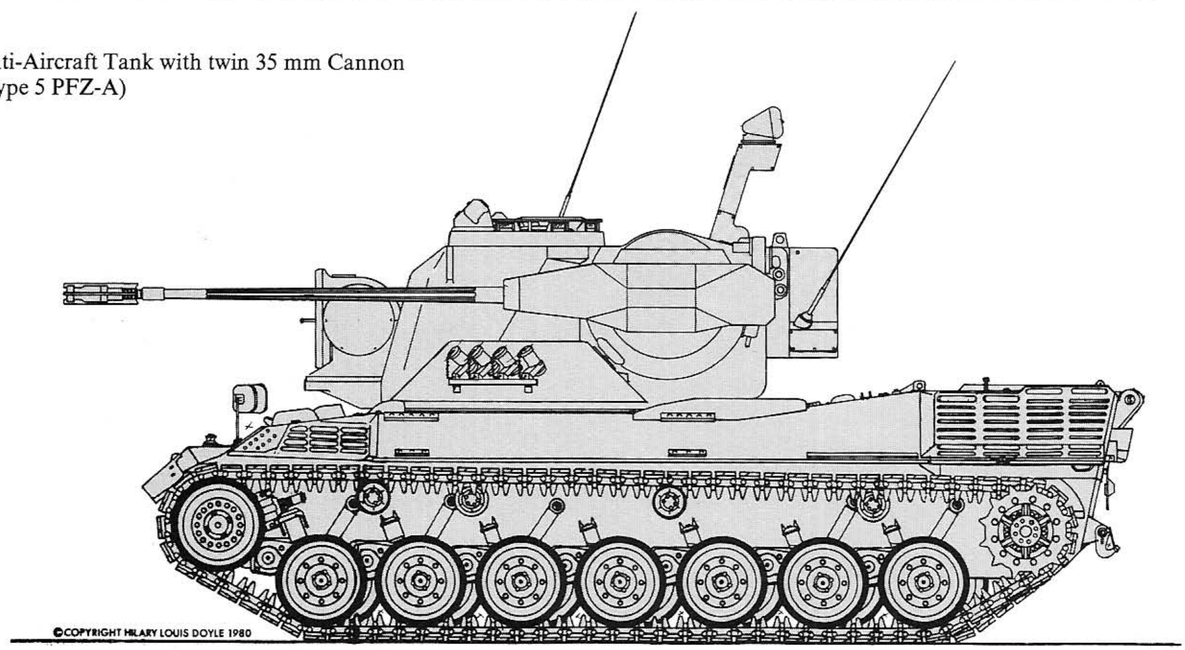
The 35 mm cannon proved itself as being an extremely sound construction with good access all round, ammunition feeding and selection of both types of the ammunition carried was established as being sure and reliable. Some improvements, however, were necessary:
☐ CO gas evacuation in the fighting compartment needed improving
☐ repeated break-down of the power supply due to constructional weaknesses in the power supply unit need eliminating

All of the improvements and modifications determined during as being necessary were very quickly introduced and completed by industry.
The following major sub-assemblies were available:

Anti-Aircraft Tank with twin 35 mm cannon
(Works Prototype)

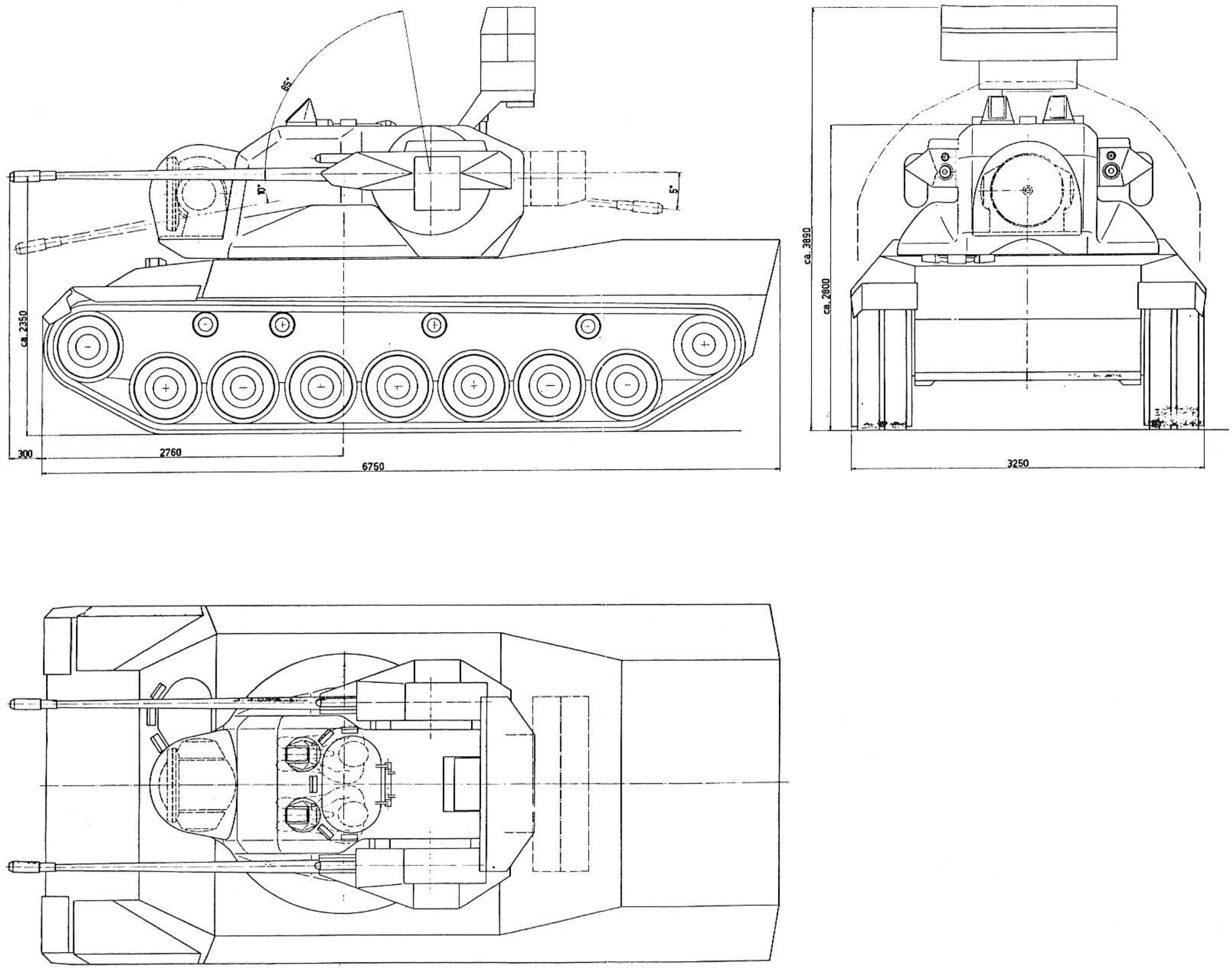


Anti-Aircraft Tank with twin 35 mm Cannon
(Type 5 PFZ-A)

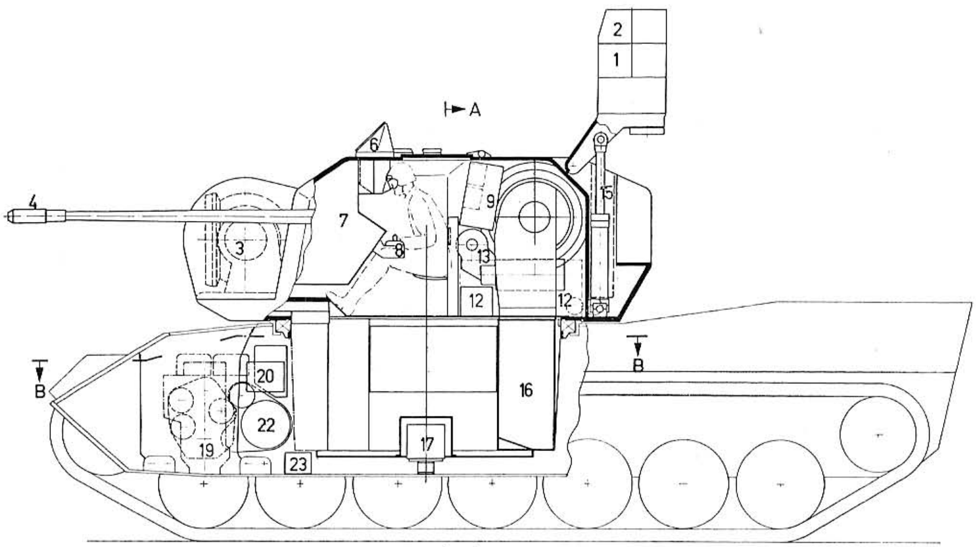


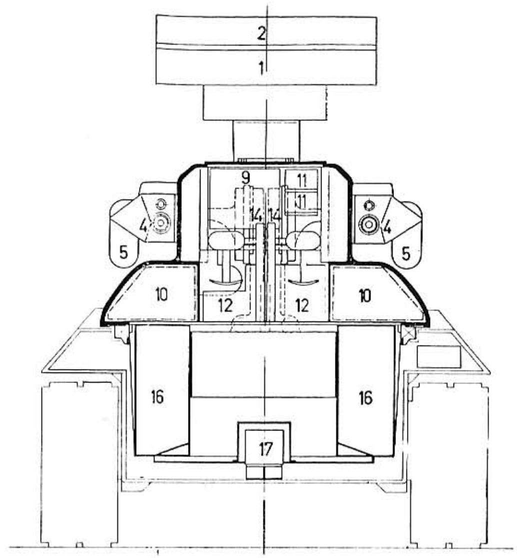
- ☐ MTI doppler surveillance radar with medium clutter suppression (Hollandse Signaal Apparaten)
- ☐ frequency diversity tracking radar (Siemens-Albiswerke)
- ☐ fire controly system including computer (Contraves)
- ☐ 35 mm twin cannon weapon system (Oerlikon)
- ☐ cast steel turret (Oerlikon)
- ☐ modified Leopard MBT chassis (Krauss-Maffei)

The extremely satisfactory results obtained during the first and second phases of the trials enabled the trials authorities to undertake gunnery trials with both of the 5 PFZ-A's in September 1969. These trials took place at the NATO Anti-Aircraft Ranges in Todendorf/Schleswig-Holstein (Baltic Coast). Evaluation of the hit results attained by both prototypes which had been build for the German Armed Forces against high speed targets travelling at (180 m/s), at ranges of up to 4,000 mtrs. confirmed the firing precision demonstrated

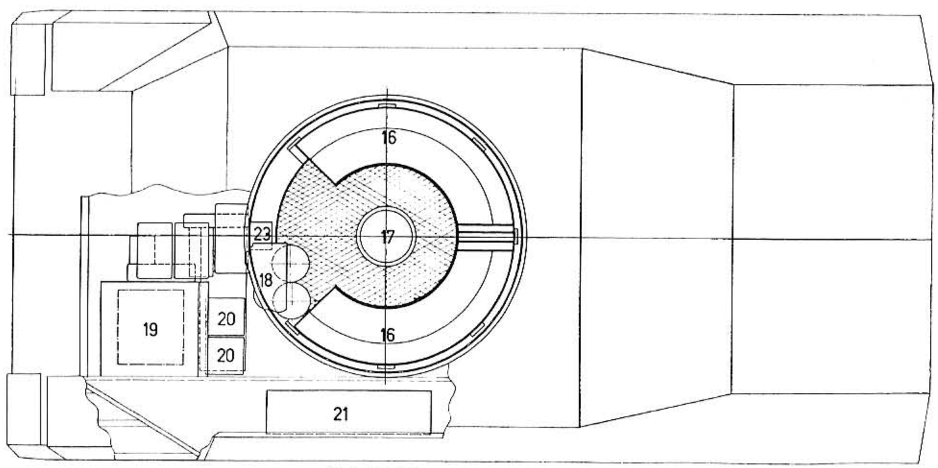


Oerlikon-Contraves Works Prototype 5 PFZ 35 mm Anti-Aircraft Tank in all three elevations.





Schnitt A÷A

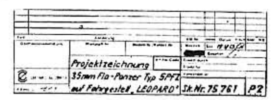


Schnitt B÷B

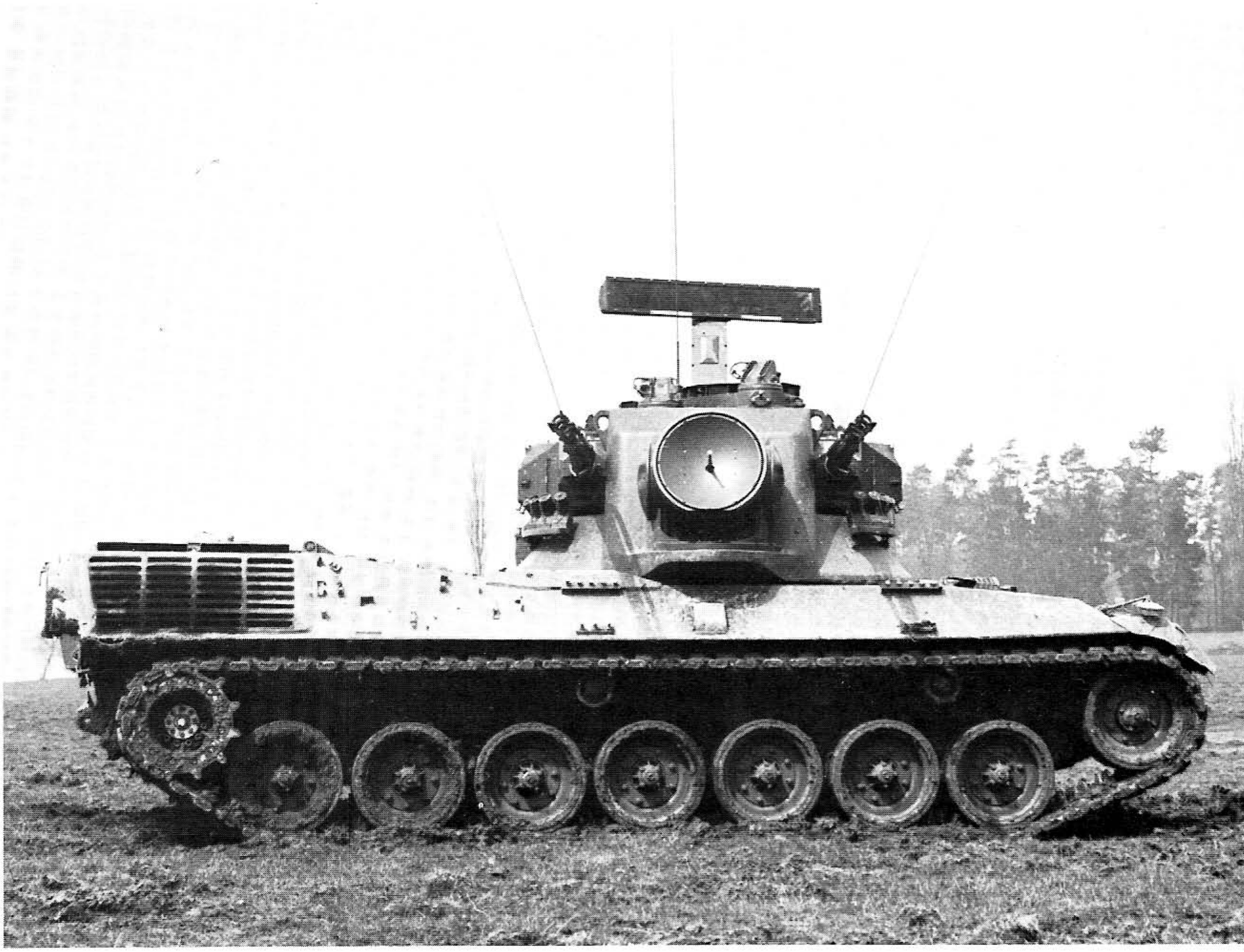
Section A-A

Section B-B

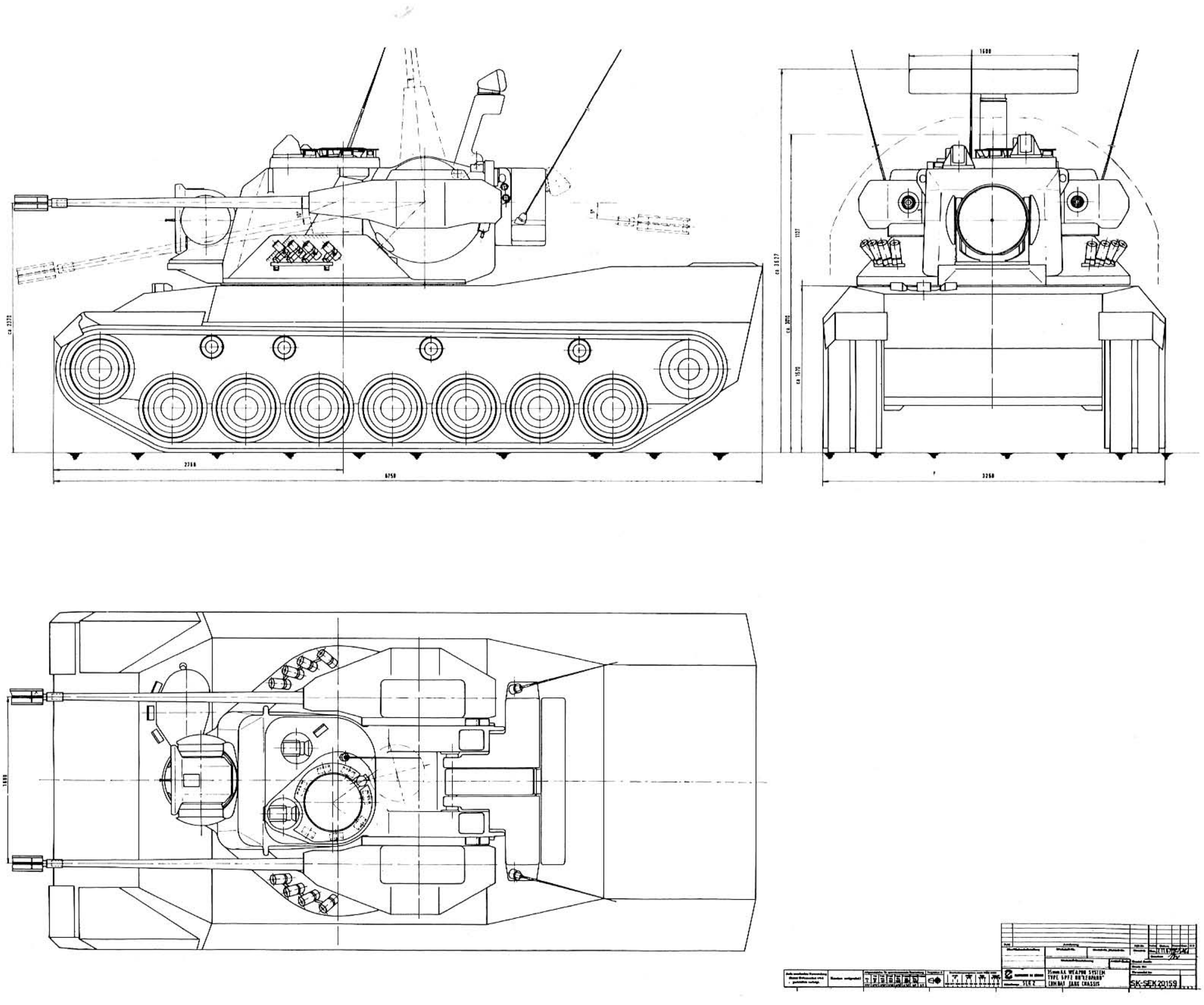
1 Search Radar
2 IFF Unit
3 Tracking Radar
4 35 mm Belt Fed Cannon
5 Ext. Magazines for AP Ammunition
6 Periscope
7 Tactical Display Operations Console
8 Joy-stick
9 Computer
10 Transmitter/Receiver for Tracking Radar
11 Warning Receiver
12 Turret Drive electrics
13 Weapon Elevation Drive
14 Ammunition Feed Chutes
15 Weapon Counter Balances
16 AA Ammunition Magazines
17 Turret Slip Ring
18 Turret Traverse Drive
19 Auxiliary Engine
20 Battery Circuit FLA System
21 Static Converter
22 Metadyne Generator
23 Cant-Angle Measuring Unit



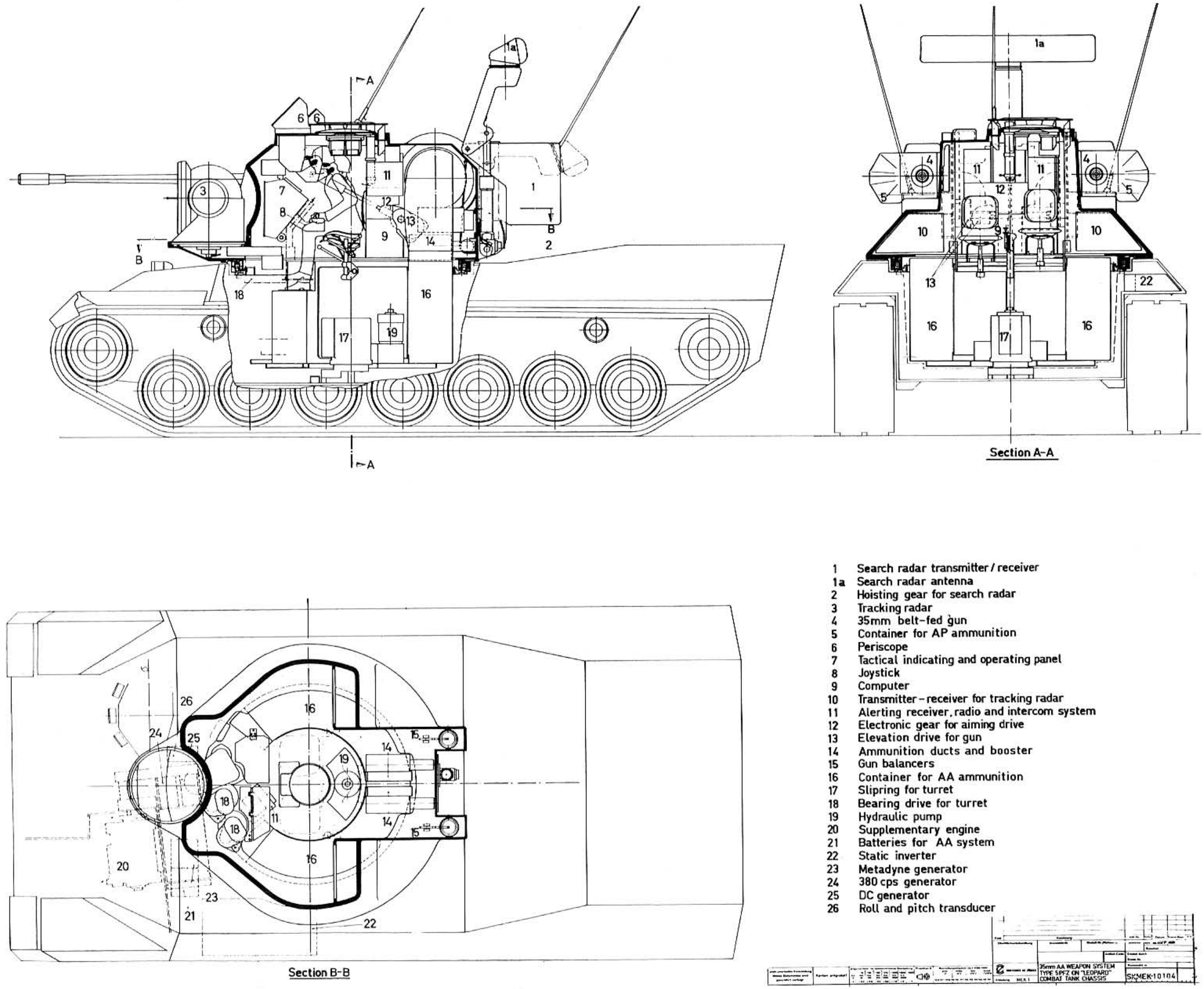
Cross-sectional views of the Works Prototype Anti-Aircraft Tank



Three views of the Type A 35 mm Anti-Aircraft Tank mounted on the Leopard chassis (Type 5 PFZ-A).



Anti-Aircraft Tank Prototype 5 PFZ-A in all three elevations.



Cross-Sectional views of the 5 PFZ-A Anti-Aircraft Tank Prototype.

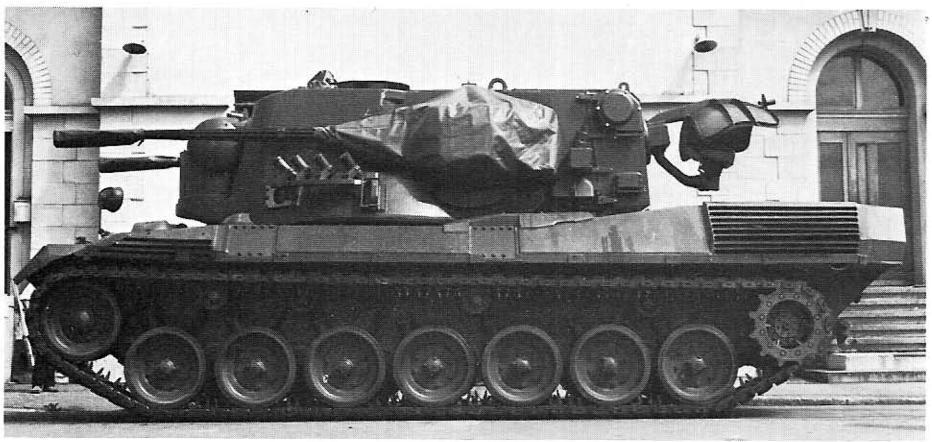
earlier in the Swiss trials with the works-protoype. In February 1970, these joint trials were completed. These were shortly followed by tactical/technical trials with the Army, such acceleration of these trials was only possible due to a partial troop trials program having taken place parallel to the technical trials.
Thereafter the weapon system was ready for introduction into service.
The technological advance in radar technology which had taken place during the interim period, particularly with respect to "clutter" suppression necessitated development of a "second generation" of Anti-Aircraft Tanks complete with the more advanced radars. However, the original technical concept established for the first generation of vehicles was retained and underwent trials at the proving facilities. The advancements in the radar equipment not only improved detection and

Wooden model of the 5 PFZ-B Anti-Aircraft Tank.

tracking of aircraft flying at the very lowest levels but also considerably reduced system reaction times.
The second generation of prototypes (5 PFZ-B) retained the already proven technical system concept for the following components:
- ☐ pulse doppler surveillance radar MPDR 12 with improved clutter suppression and range discrimination (Siemens, adopted from the MATADOR program)
- ☐ pulse doppler tracking radar, an improved version to the one used in the A-series of prototypes (Siemens, Albiswerk)
- ☐ friend/foe identification unit (IFF) MSR 400 coupled with the MPDR 12 (Siemens)
- ☐ welded turret housing using spaced armor construction
- ☐ chassis with spaced armoring incorporating major Leopard MBT standard components (Krauss-Maffei)

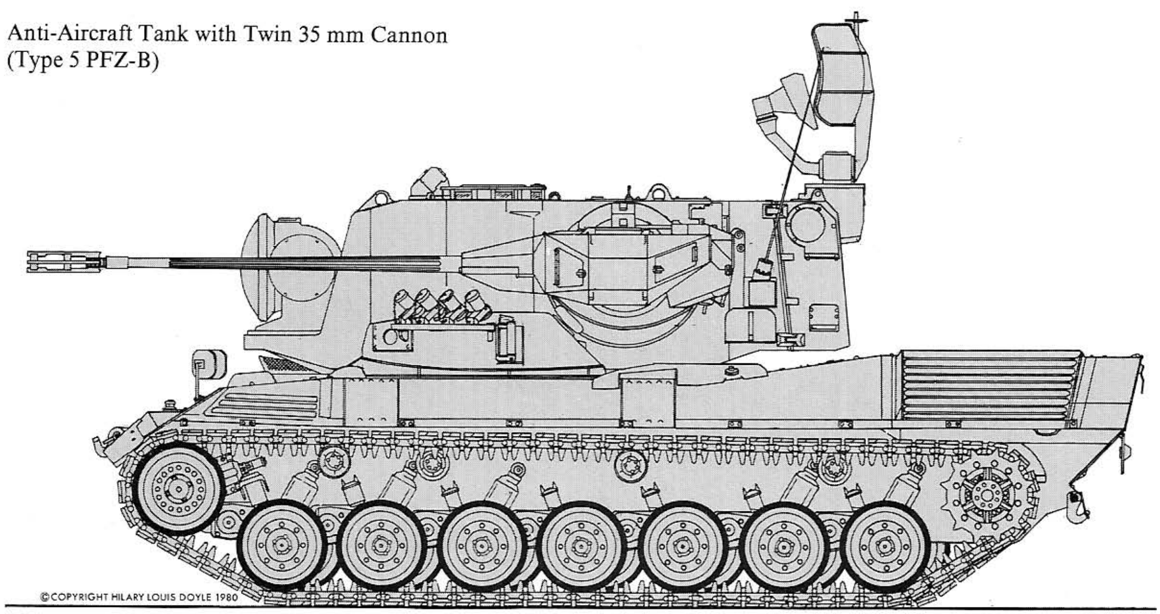
On December 23rd, 1969, the Procurement Agency (BWB) contracted Krauss-Maffei to develop and built four new chassis (PT 353 to PT 356) for carrying the Anti-Aircraft Turrets. Whereby, it was stipulated that these chassis should incorporate the maximum amount of standard Leopard MBT components and sub-assemblies as was possible. Of the four chassis ordered only that of the PT 353 was to be manufactured from armor plate, the remaining three chassis PT 354, 355 and 356 were to be constructed from mild steel plate.
Major differences between the Anti-Aircraft Tank chassis and that of the Leopard MBT were as follows:
- ☐ Alternative spaced armoring, taking fully into account the increased threat of aerial attack, additional armor applied at the front, rear and upper side walls.
- ☐ Installation of an auxiliary power supply for the additional air defense oriented equipment. Located in place of the ammunition bunker of the MBT Leopard. This comprises mainly of the auxiliary Diesel engine (Daimler Benz, type OM 314 modified), a distributor drive for driving the metadyne, two AC generators and one DC generator. This auxiliary installation was totally closed-off from the chassis interior by armored bulkheads and provided with its own external hatch and fire extinguishing system.

5 PFZ-B Anti-Aircraft Tank with wooden turret. Upper photograph with both radars locked in their "march" positions. Lower photograph with both radars and cannon in "firing" positions.



Two side views of the prototype 5 PFZ-B Anti-Aircraft Tank in the march position. The modified Leopard chassis shows the additional battery container at the rear of the main engine compartment.

Anti-Aircraft Tank with Twin 35 mm Cannon (Type 5 PFZ-B)



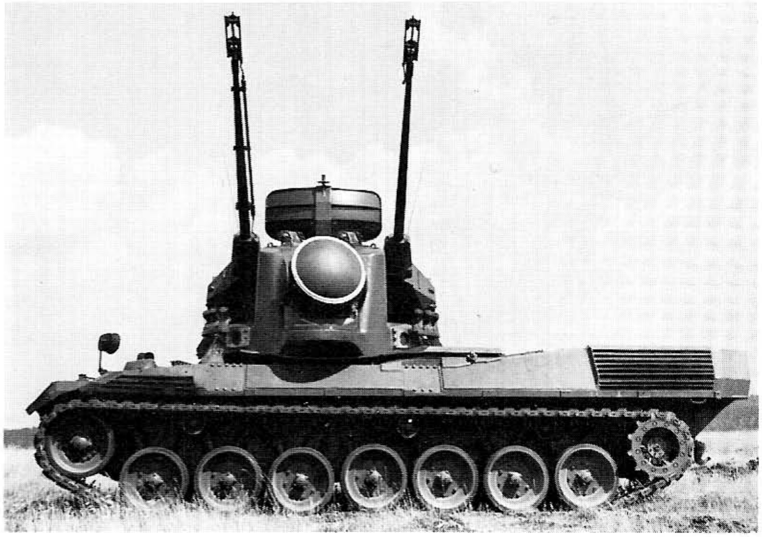
☐ The six batteries were re-located in form of an extension at the very rear of the chassis between the spaced armor, providing better access for maintenance and servicing. The space made available by doing this being used for stowing turret-oriented electrical equipment.

☐ A protective grating along the upper left side of the chassis covering the auxiliary engine exhaust.

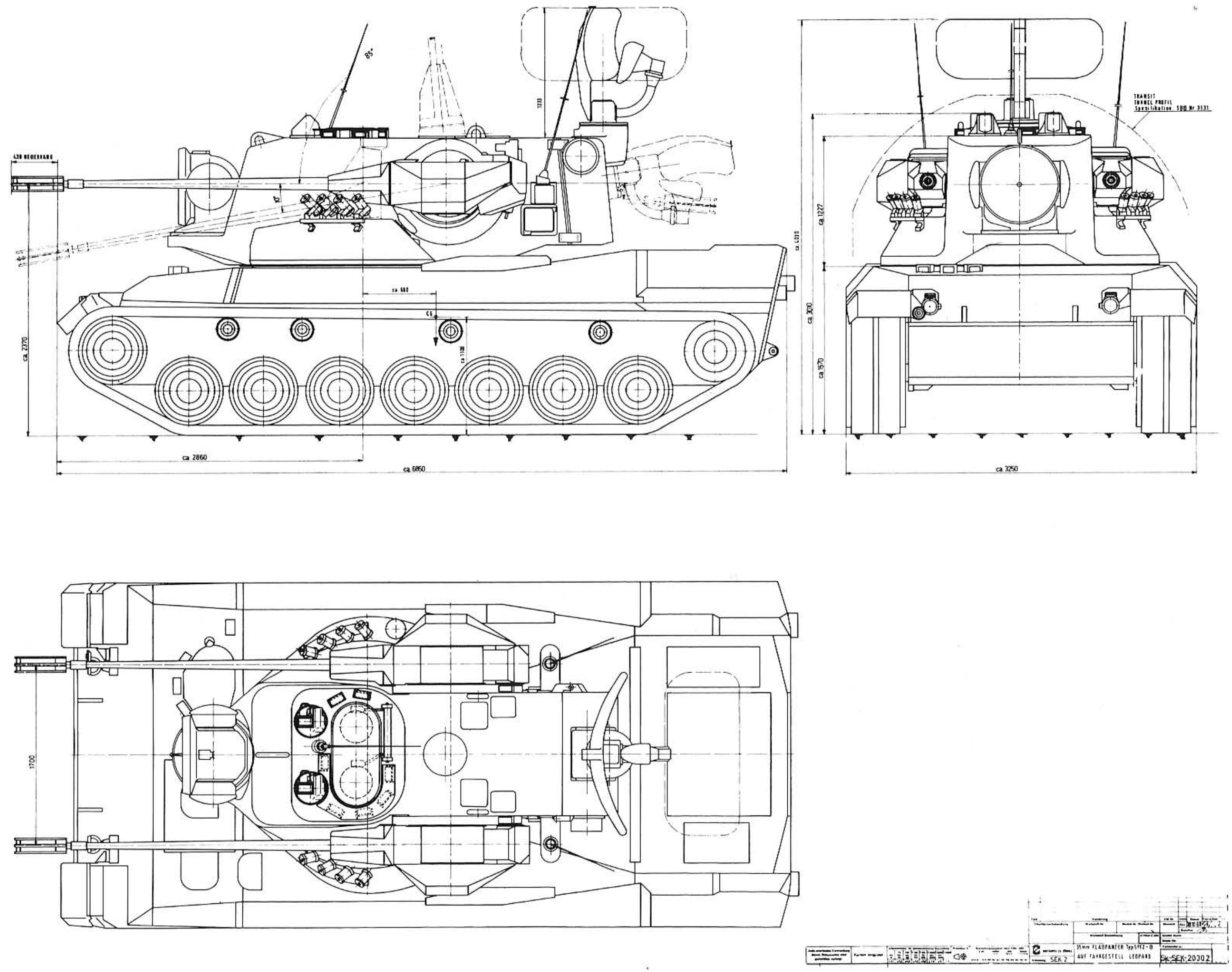
☐ An air intake shroud with watertight flap for NBC unit and auxiliary engine combustible air to the front upper left of the chassis.

☐ A second air intake shroud with watertight flap at chassis deck level on the left front section for ventilating generators, power supply, Metadyne and auxiliary engine compartment. Exhaust air being discharged via the exhaust grill in the forward left, side wall of the chassis.

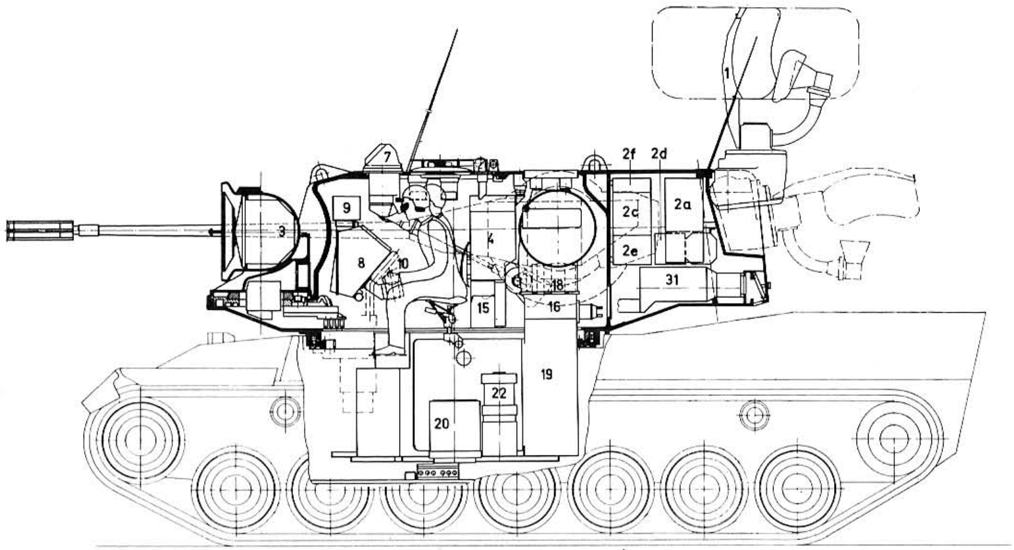
☐ Re-positioning of various control elements of the driver's cockpit (necessitated because of the totally enclosed A-A Turret well) e.g.: deep wading hydraulic pump, main electrical power switch, remote fuel tank switch, heater and engine pre-warming switch.

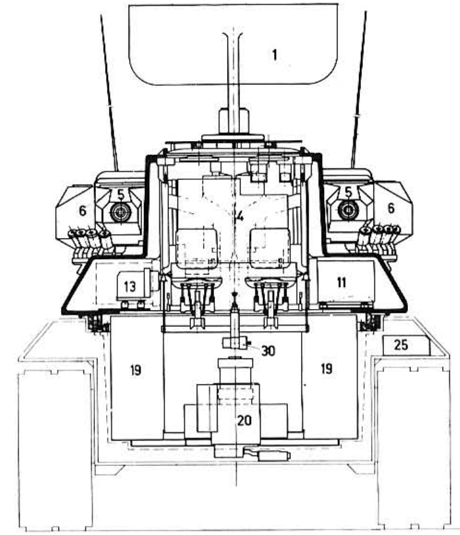


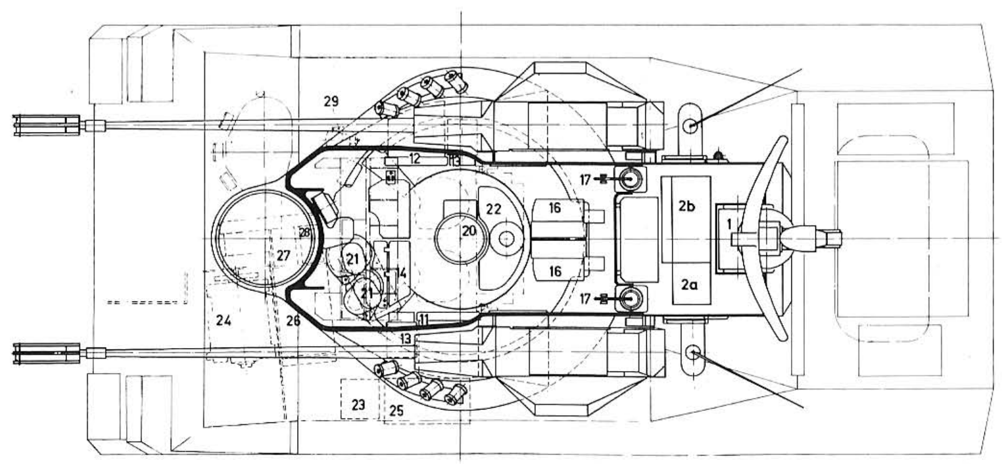
Prototype 5 PFZ-B Anti-Aircraft Tank in "firing" position. Upper photograph shows tracking radar without, lower with protective radome.



Three views of the Prototype 5 PFZ-B Anti-Aircraft Tank.







1 Search Radar Antenna with Pedestal
2 Search Radar Components IFF Unit
a) Transmitter, b) Power Supply, c) Receiver, d) Cooling Ventilation, e) IFF, f) Data Transmission
3 Tracking Radar Director
4 Tracking Radar Transmitter/Receiver
5 35 mm Belt-fed Cannon
6 External Special Ammunition Magazines
7 Periscope
8 Tactical Display and Operations Console
9 IFF Operation Section, Search Radar Monitoring, Compact radio unit, FNA Operation Section
10 Joy-stick
11 System Electronics, Logic
12 Tracking Radar, Fuse Box
13 Radio Receiver
14 Radio Transmitter/Receiver
15 Computer
16 Ammunition Feed Chutes Booster
17 Weapon Counter Balances
18 Weapon Elevation Drive
19 A-A Ammunition Magazines
20 Turret Slip-Ring
21 Turret Traverse Drive
22 Hydraulic Unit
23 Metadyne Control Electronics
24 Auxiliary Engine
25 Static Inverter
26 Metadyne Generator
27 380 Hz Generator
28 Charging Unit
29 Cant-Angle Measuring Unit
30 Emergency Outlet and Brake
31 Heat Exchanger

Longditudinal and Cross-Sections of the 5 PFZ-B Anti-Aircraft Tank Prototype

TABLE 8: 35 mm Anti-Aircraft Tank – Type Comparison (Status September 1974)

	A	B	C (NL)	B	B1
Chassis	Leopard Modified	Leopard Modified	Leopard Modified	Leopard Modified	Leopard Modified
Surveillance Radar	HSA	MPDR 12 (45 r.p.m)	HSA	MPDR 12 (60 r.p.m + ED)	MPDR 12 (60 r.p.m. + ED)
Fire Control Radar	Albis Conical	Albis Conical	HSA PD + Tracker	Albis Conical	Albis Monopulse PD
	Scan.Freq-Div.	Scan, PD	Radar	Scan, PD	PD
Computer	Contraves	Contraves	Contraves	Contraves	Contraves
Optical Directors	2 periscopes	2 periscopes	2 periscopes	2 periscopes	2 periscopes Laser
Weapons	Oerlikon 35 mm	Oerlikon 35 mm	Oerlikon 35 mm	Oerlikon 35 mm	Oerlikon 35 mm

- ☐ Connecting the auxiliary engine to the main fuel supply and cooling circuitry of the main engine. With only the auxiliary engine running the cooling fan for cooling the main engine could be driven independently via a hydraulic drive if required.
- ☐ Provision of a swivelled, discardable protective cover over the driver's hatch as a safety measure during turret traversing operations when the driver's hatch was open.
- ☐ A circular collar on the chassis which was formed to the contours of the turret as a guard against the turret jamming due to used cartridge cases or belt clips while firing.
- ☐ Fitting of mechanical shock absorbers at the suspension arm positions 2 and 6 in place of the Leopard hydraulic shock absorbers. This was done to inhibit hull deck movement during firing.

In the period end of 1970 beginning 1971 three prototype chassis were delivered to Oerlikon-Contraves. The PT 353 chassis was handed over to the German Armed Forces Proving Ground No 41 at Trier after works trials had been completed for continued testing. The prototype chassis 304 from the 30 mm Matador program was adapted to suit the 35 mm system and received the number PT 358. this adaptation work was completed on October 18th, 1971, and this chassis remained in the possession of Krauss-Maffei for carrying out works trials. Completion of the second generation of anti-aircraft tanks 5 PFZ-B by Oerlikon-Contraves followed in Autumm of 1971. From 1971 until 1974, technical and field tests were carried out with the aim of optimising the system which also led to even shorter re-action times and improved immunity to electronic interference. Immediately after which the four "B" prototypes were tested parallel to the "C" prototypes.

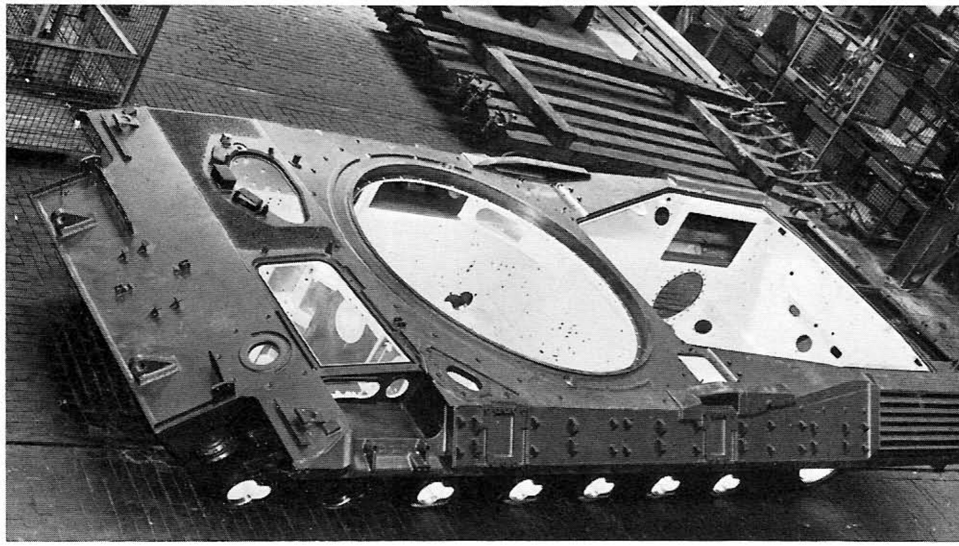
On February 24th, 1970, Krauss-Maffei informed BWB of the numbers which had been allocated to the 35 mm prototype chassis.

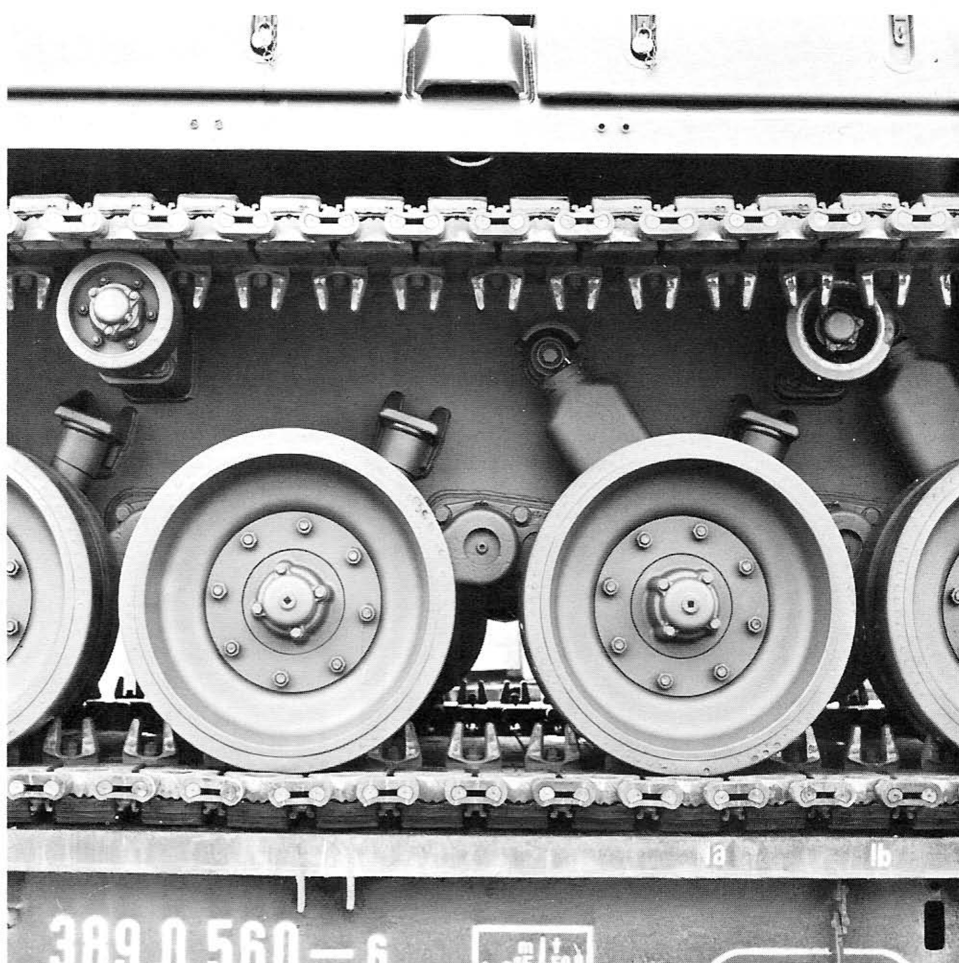
PT 351 = protoype I Chassis No. L-0-33
Type 5 PFZ-A
PT 352 = prototype II Chassis No. L-0-14
Type 5 PFZ-A
PT 353 = 1. new chassis in armor steel
Type 5 PFZ-B
PT 354 = 2. new chassis in mild steel
Type 5 PFZ-B
PT 355 = 3. new chassis in mild steel
Type 5 PFZ-B
PT 356 = 4. new chassis in mild steel
Type 5 PFZ-B
PT 357 = Dutch Anti-Aircraft Tank chassis
No J-016 type 5 PFZ-C
PT 358 = converted Matador hull PT 304
Type 5 PFZ-B

5.5.3.2 Pre-series Anti-Aircraft Tanks

The experience gained from the trials of the four B-prototypes was integrated into the 12 pre-series vehicles which the Procurement Agency (BWB)

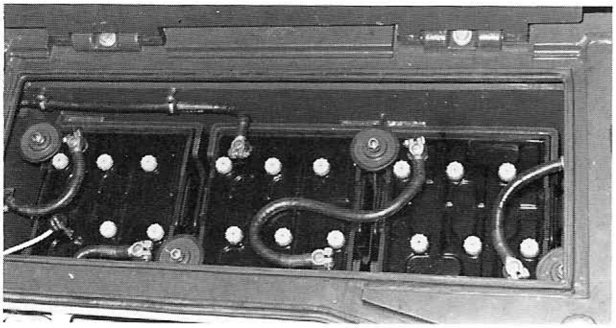
The hulls delivered completed to Krauss-Maffei were common to both the Gepard and CA 1 versions of the A-A Tank.





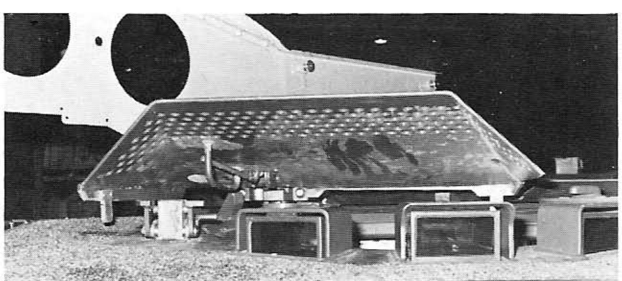
The increased pitch between third and fourth road wheels, one of the differences between the Leopard MBT and Gepard A-A Tank chassis.

had ordered at the end of 1970, for the sum of 90 million DM. Five of the vehicles ordered were to be pre-series B 1 systems, the remainder were to be B 2R systems (B 1 systems had conical scanning, B 2R with optimized mono pulse). This direct contract between the Procurement Agency (BWB) and Oerlikon-Contraves stipulated that all these pre-series vehicles were to be delivered directly by Oerlikon-Contraves to BWB.


The batteries stowed between the cavity walls of the spaced armor also received armored protection.

Driver's Hatch in the battered down position, with three vision blocks.


The Driver's Protective Shroud in position over the open Driver's Hatch.



This decision was amended in March, 1973, when it was decided that all 12 pre-series vehicles were to confirm to the B 2 system configuration. Naturally the pre-series pre-production planning had to be revised to accommodate this. When compared with the prototypes the technical requirements for the pre-series vehicles included some quite extensive alterations. The Procurement Agency (BWB) specified that the weight of the chassis be fixed at 32 t, total weight of the A-A Tank complete established at 45.5 t. Due to these weight restrictions being imposed both turret and hull had to be considerably lightened, whereby the originally proposed increased armored protection requirement was reviewed and reduced.

These reductions meant re-calculating and re-stressing the hull construction and gauges of armor plate to ensure that the hull retained its structural rigidity. This was carried out using the Finit-Element Method of calculation. Once again as with the prototypes, the maximum incorporation of Leopard MBT components and sub-assemblies was specified.

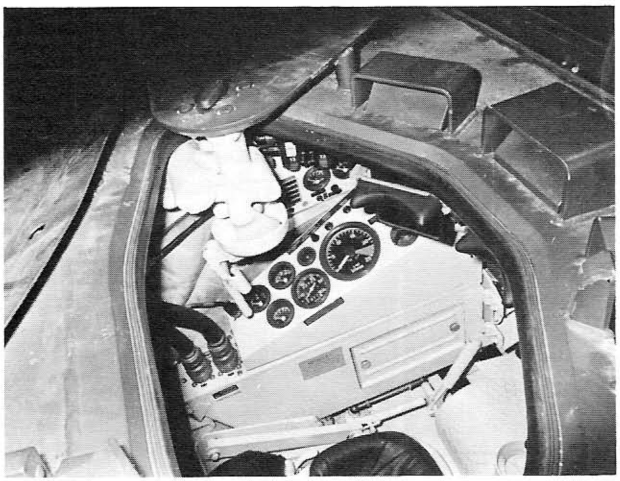
Compared to the PT 353 to PT 358 prototypes the following improvements were carried out:
The hull was lengthened between the third and fourth road wheels by 80 mm, the turret mounting ring moved 20 mm forwards to facilitate installation of sound absorbing protection between the driver's cockpit and auxiliary engine compartment. 12 hydraulic/mechanical shock absorbers replaces the six hydraulic and four mechanical shock absorbers originally used, the aim being to inhibit hull movement during firing as much as possible. The tracks were increased in length by one link making to eighty-five links in all, one link more than on the standard Leopard MBT track.

As with the prototypes, the six vehicle batteries were stowed at the rear of the vehicle between the inner and outer spaced armor. They were now also brought under protective armor covering. The ex-

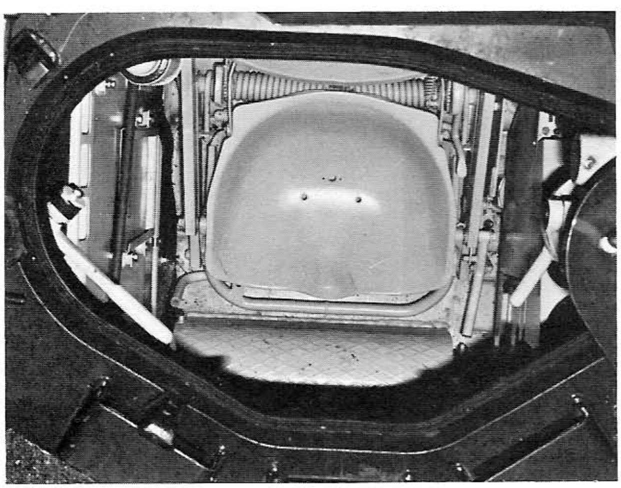
haust pipe of the auxiliary engine was increased in size, fitted with an additional silencer and via an elbow fed back to the left hand main engine exhaust grating. The objective was to eliminate exhaust fumes from being drawn into the vehicle when the wind direction was unfavorable.

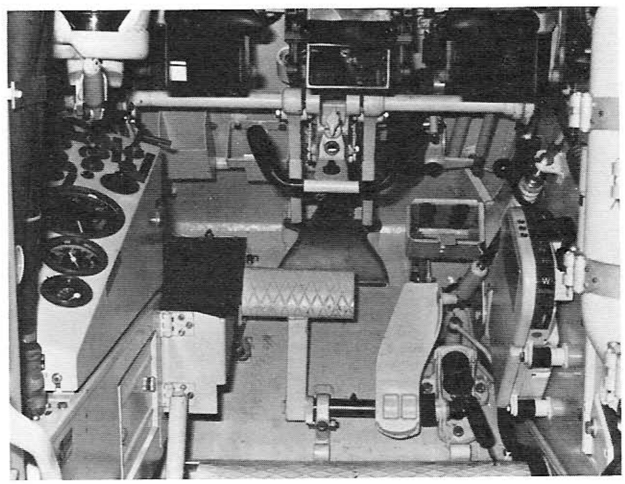
The various changes and alterations necessitated by the air defense application, driver's cockpit layout, protective hatch grill, shell deflector collar etc. were all optimised. Tools and other vehicle equipment were stowed in seven metal tool-boxes, four along the upper right chassis side wall, one along the left and two at the rear below the battery compartment. Both of the rear tool boxes were integrated under the outer cladding of the chassis.

After the six vehicle batteries had been relocated toward rear of the vehicle, an electrically powered, inductive, battery heating system was included.
In view of the expected series production of the Anti-Aircraft Tanks, a contract was signed in Autumm 1971 between the newly established AA Tank project Office of the Procurement Agency (BWB) and the Oerlikon-Contraves group. Whereby, the pre-production planning and technical responsibilities for the weapon system were contractually agreed.



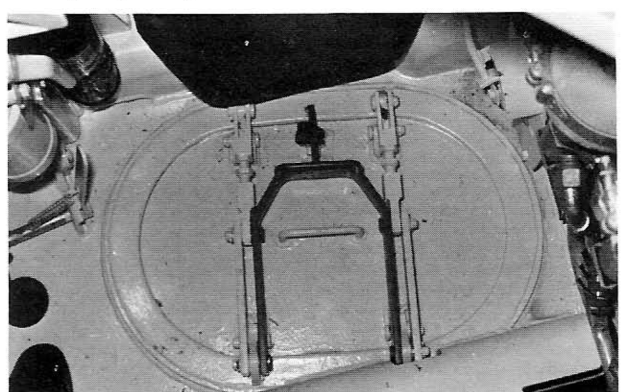
View through the open Driver's Hatch, above the Control Panel, below the Driver's Seat (minus cushion).





Driver's cockpit layout with operation controls, vision blocks and fire extinguishers for the engine compartment (right).

Emergency Escape Hatch behind the driver's seat.



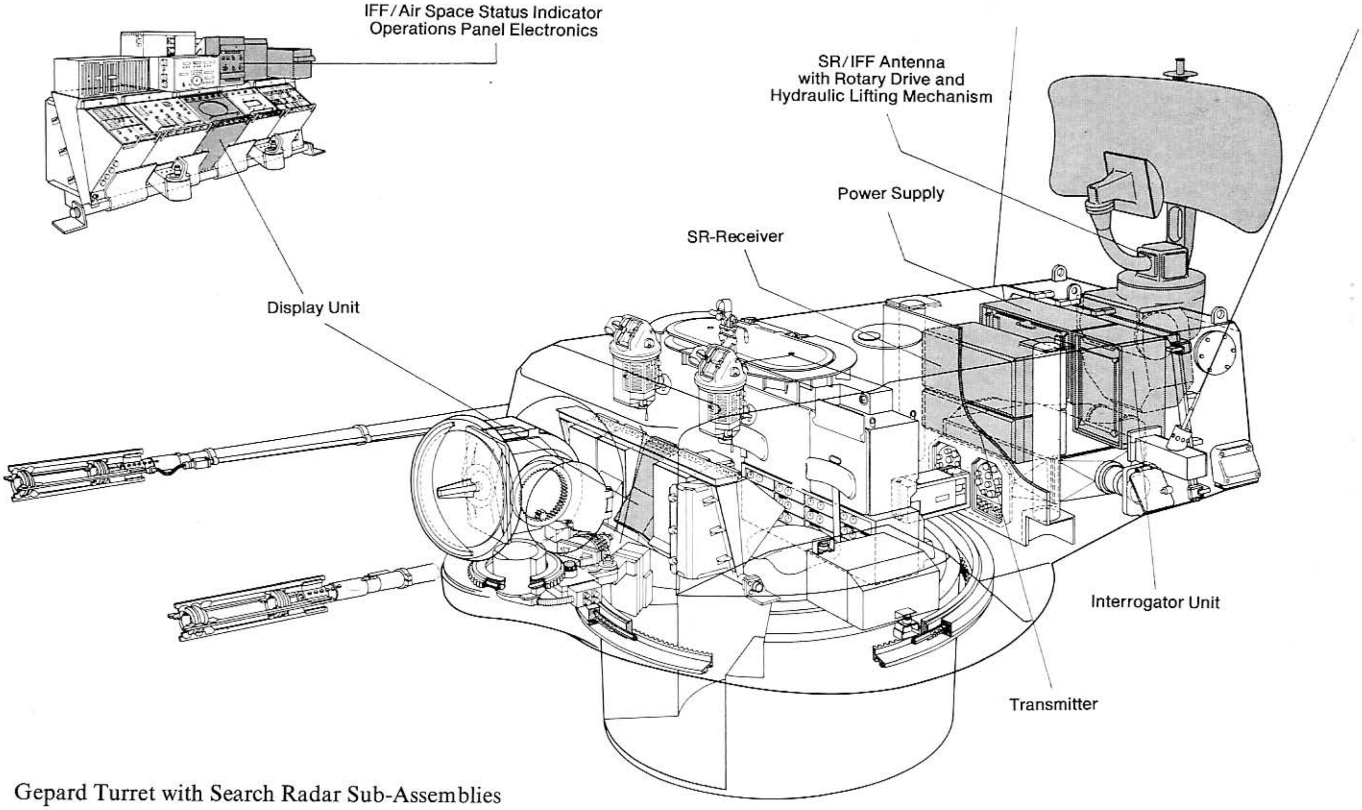
In anticipation of series production of the weapon system, two candidate industrial consortiums sought nomination as General Contractor. The first consortium was composed of the Bührle Group together with Siemens AG, Wegmann and MaK Machine Tools, the second consisted of Krauss-Maffei AG, AEG-Telefunken, Keller and Knappich and Honeywell. Both consortiums presented their nominative General Contractor's Series Production Tenders in May 1972 to the German Ministry of Defense. The cost per system quoted was 3.6 million DM.

Technical Description of the 35 mm Anti-Aircraft Tank

The Gepard Anit-Aircraft Tank is an autonomous air defense unit, autonomous in this case meaning that the system is capable of independent aerial surveillance, engagement alert together with target acquisition, friend/foe interrogation (IFF) and threat evaluation.

The weapon system itself is stowed within the specially designed anti-aircraft turret which in turn is mounted upon a modified Leopard MBT chassis. In the main, each system consists of the surveillance radar, fire control system complete with computer and the twin 35 mm weapon system. The three man crew comprises a commander, gunner and driver.

Major elements of the fire control system are the search and tracking radars, computer, muzzle velocity measuring device, terrestial navigator, cant angle measuring unit and optical gun-laying equipment.
The Siemens MPDR surveillance radar with its raisable antenna establishes the autonomous capability of the weapon system. This radar is operable when the system is moving or stationary, providing reliable and continuous monitoring of the surrounding air space complete with IFF recognition. Initial detection of an aerial target leads automatically to the crew being alerted.



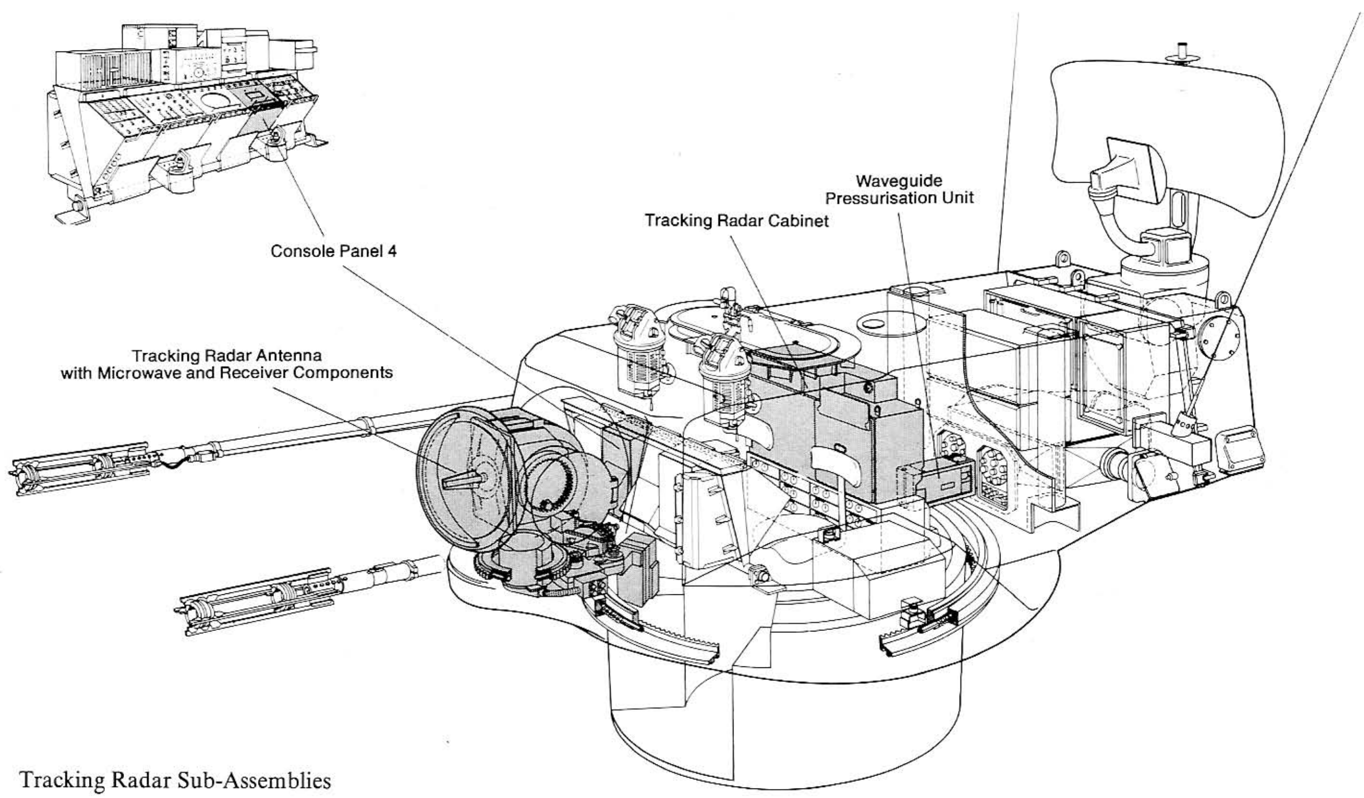
Gepard Turret with Search Radar Sub-Assemblies

The surveillance radar is composed of the following sub-assemblies:

- ☐ combined surveillance radar and IFF antenna
- ☐ transmitter/receiver and power supply
- ☐ PPI (display) and operating console.

Via the PPI display aerial target data is illustrated to the turret crew in both range and azimuth. Simultaneously to this the target's status as friend or foe is also established and shown on the display. Precise target assignment from the surveillance to the tracking radar can follow, either fully automatically or manually. When the relevant auxiliary equipment is installed, data from other external military aerial surveillance sources can be received, as digital data via radio. This data can then be shown in its correct geographical relationship on the PPI display. The armor protected Siemens-Albis pulse doppler tracking radar acquires and tracks a designated aerial target in azimuth, elevation and range. During this operation aerial surveillance with the surveillance radar continues and is not affected in any way. The wide acquisition area of the tracking radar permits targets being acquired within a 200 degree radial sector without needing any traversing of the turret, an invaluable aid in minimising the reaction time of the system.

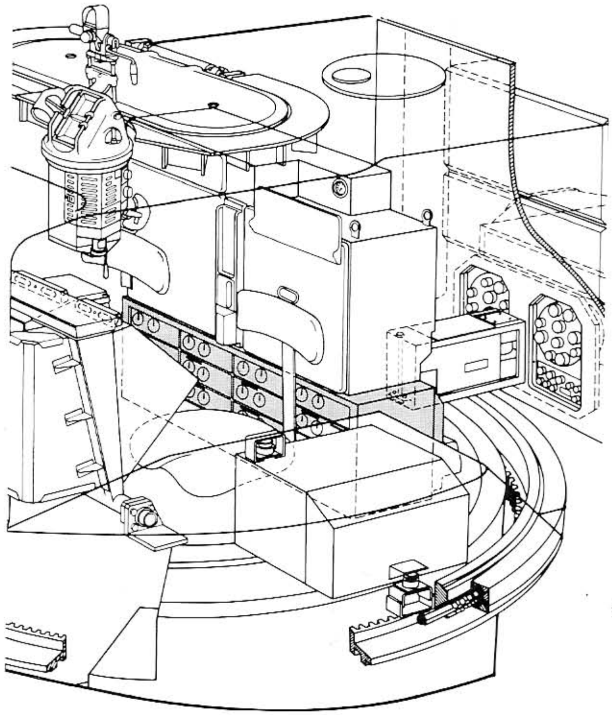
The narrow radar lobe and small range-gate facilitate good multiple target resolution. Secondary target selection is possible by pre-positioning the relevant target marker on the secondary target selected. Thereafter acquisition and tracking can take place completely automatically when desired. Target acquisition, even under the most difficult permanent echo interference conditions is assured. The tracking radar director assembly is a robust armored steel construction. The more fragile plastic radome can be rotated to face the turret when not in use and during field operations, in order to prevent damage from obstructions likely to be encountered when on the march.



Tracking Radar Sub-Assemblies

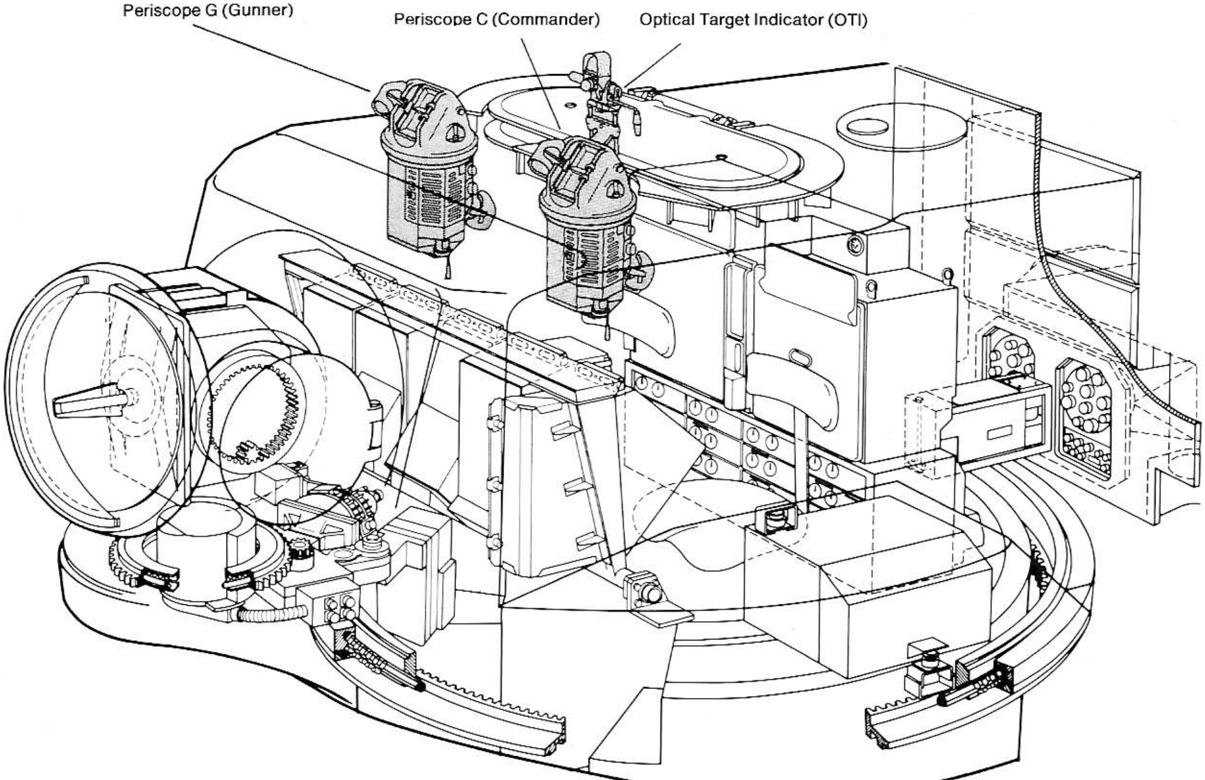
Both the commander and gunner are furnished with their own individual periscopes. These periscopes serve for the optical acquisition and tracking of either air or ground targets, they can additionally be used for terrain observation. These periscopes lines-of-sight are gyroscopically, space stabilised, enabling terrain observation and ground target engagement to take place while on the move.

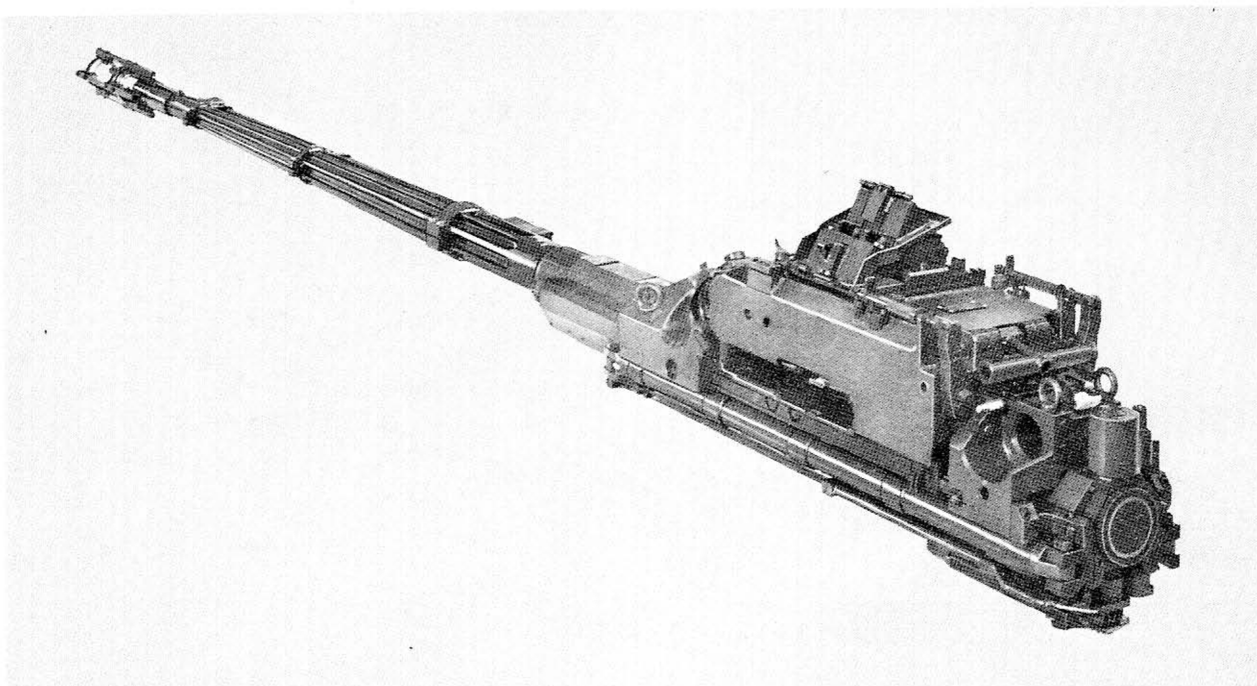
The miniaturised, transistorised analogue computer calculates the lead angles for the guns, taking into account the various meteorological influences, the continually measured muzzle velocity values and vehicle cant angles. These precise, almost instantaneous electronic calculating pro-



The fire control computer is installed behind the fighting compartment seats

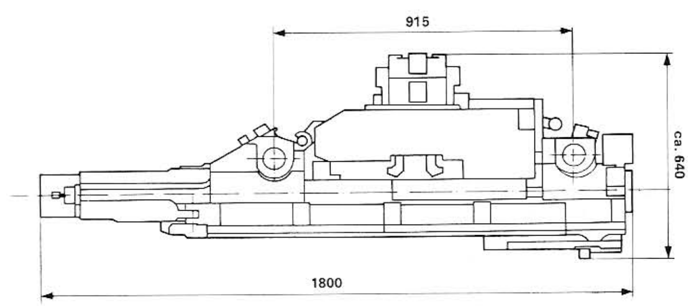
Both periscopes and the optical Target Indicator serve as the optical aiming aids for the weapon system

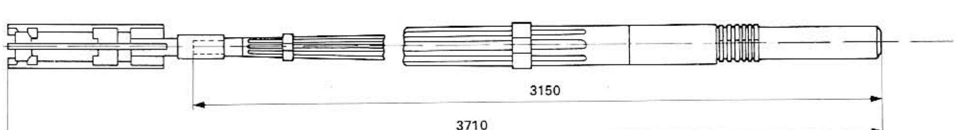


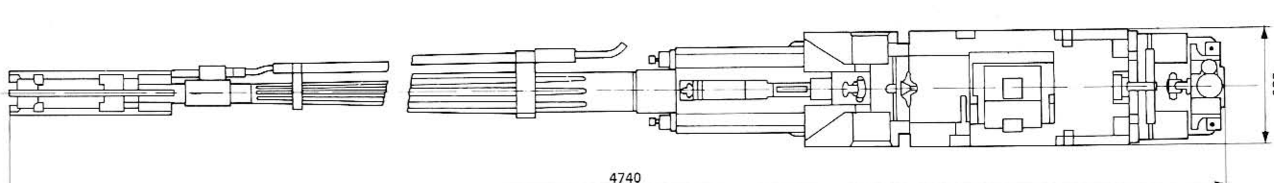


The Oerlikon 35 mm Type KDA Machine Cannon is a positively locked, gas operated weapon with two breech locking catches.

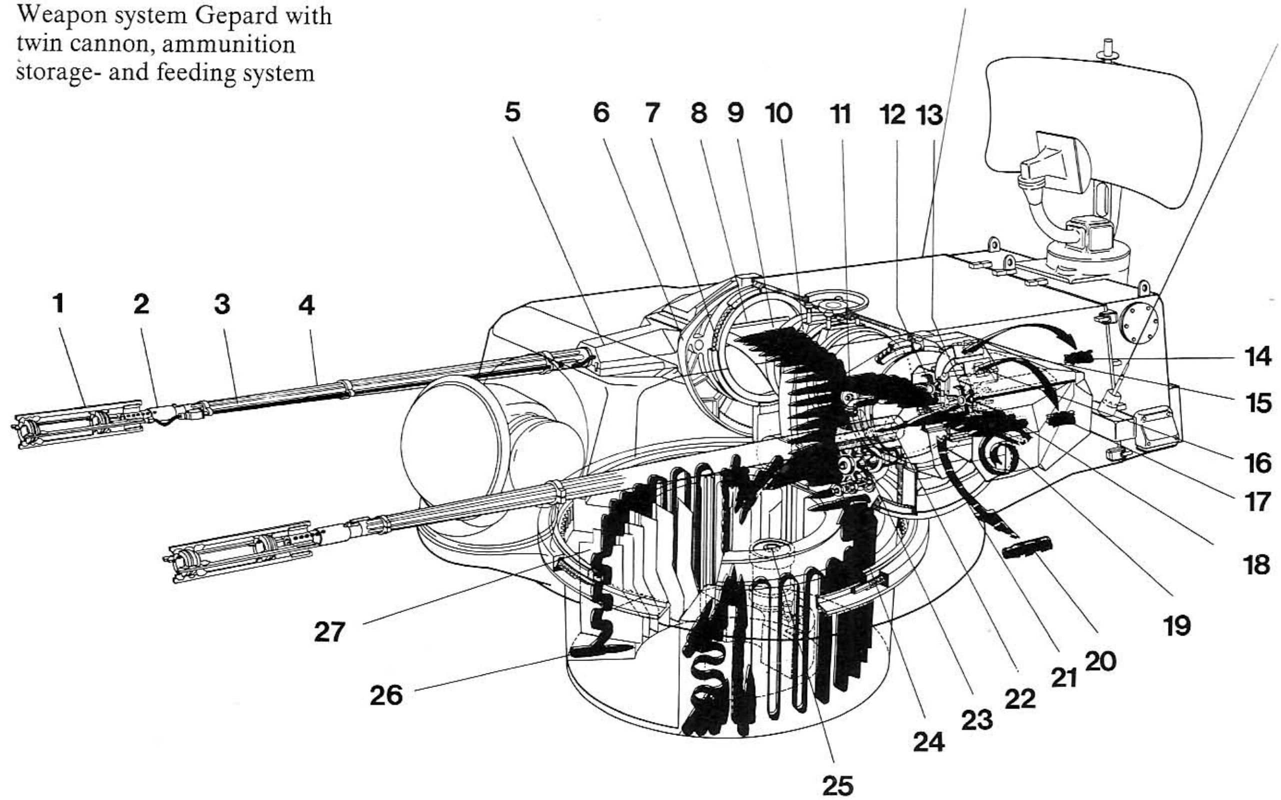
The dimensions of the 35 mm KDA Machine Cannon (in millimeters)







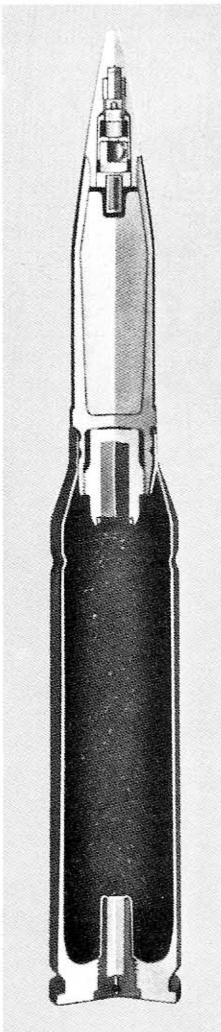
Weapon system Gepard with twin cannon, ammunition storage- and feeding system

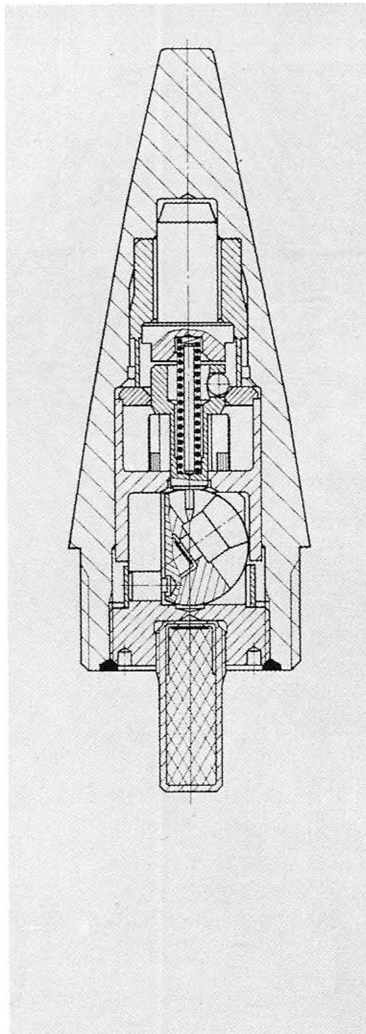


1 V_0 measuring base
2 Muzzle brake
3 cable guidance
4 barrel
5 armored cover
6 cradle
7 trunnion bearing
8 cradle base
9 flexible belt channel
10 solid belt channel
11 belt roller
12 Feed sprocket, AA-ammunition
13 Feed sprocket, AP-ammunition
14 belt link, AA-ammunition
15 cartridge case ejection hatch for belt links (AA-ammunition)
16 cartridge case ejection hatch for belt links (AP-ammunition)
17 belt link-AP-ammunition
18 AP-ammunition
19 AP-ammunition Storage
20 cartridge case
21 ejection opening, cartridge case
22 cartridge storage
23 booster
24 guide roller
25 hydraulic energy device
26 AA-ammunition
27 AA-ammunition storage

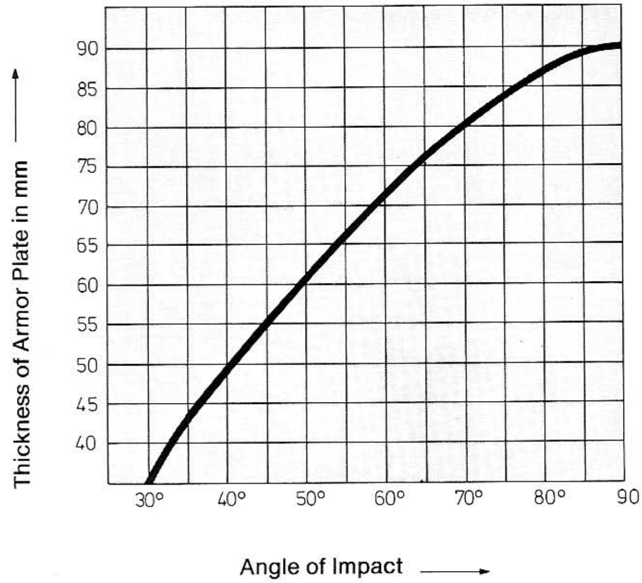
cesses, combined with the extremely favorable dispersion characteristics of the 35 mm weapons, were of major importance in establishing the high hit probability of the system. Simultaneously with the various other data processing operations the computer determines the duration of the bursts of fire from the weapons, according to the range of the target. This serves to ensure the most economical use of the ammunition available.

Each complete weapon system embraces the twin mounted 35 mm L/90 machine cannon, ammunition feed chutes and ammunition magazines. One weapon is externally mounted on each side wall of the turret these are elevatable from –8° to +85°. The weapons use steel-link, belted ammunition. By externally mounting the weapons any possible build-up of toxic fumes occurring within the turret during firing are prevented plus providing easy all-round access to the weapons for maintenance and repair. Damageable parts of the weapon (breech etc.) are protected with armored steel housings. The 35 mm belt-fed Oerlikon cannon is





35 mm High Explosive Incendiary Ammunition HEI-T with Fuze and Detonator.



Performance of the Armor Piercing Shell measured at a range of 1,000 meters.

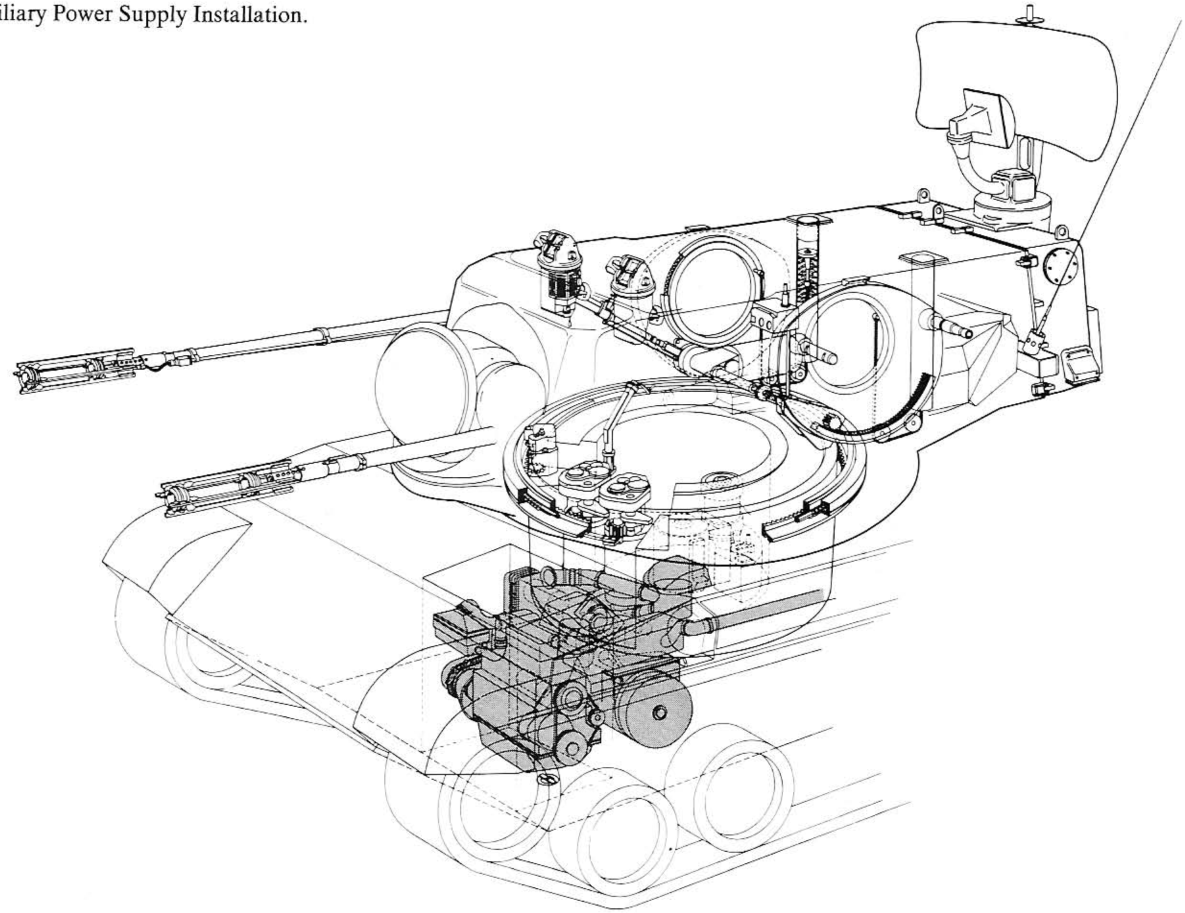
a high performance, gas-operated weapon with a firing cadence of 550 rounds per minute and a muzzle velocity of 1175 meters per second.

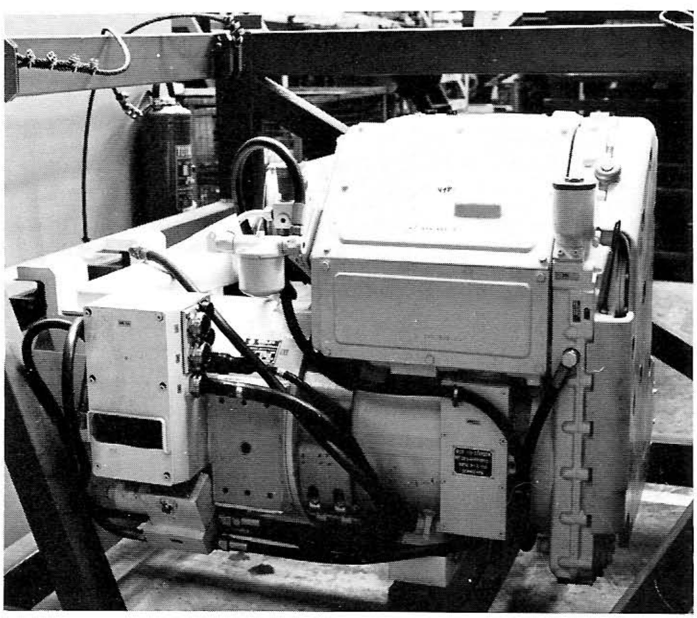
The ammunition feeder mechanism permits easy selection of either belted, aerial target ammunition from the magazines in the turret well or armor piercing ammunition from the external magazines. Switching from one kind of ammunition to the other is remotely controlled from within the turret fighting compartment. Installed at the muzzle of each connon are muzzle velocity measuring devices which enable the velocity of every round fired to be measured and fed into the computer as reference data. The turret well is constructed to serve as anti-aircraft ammunition magazine. A complete ammunition re-load by the crew takes approximately twenty minutes, whereby the pre-belted rounds are fed into the guide chutes from outside the vehicle down into the turret-well section magazines. The armor-piercing ammunition is stowed in armored magazines mounted outboard of each of the gun breeches. In all, the vehicle carries six hundred and forty rounds of ready to fire A-A ammunition (320 rounds per weapon), and forty rounds of magazined AP ammunition (20 rounds per weapon). Total weight of ammunition carried is approximately 1.1 t.

High Explosive Incendiary (HEI) or Armor Piercing Incendiary (API) rounds with or without tracer can be fired as desired.

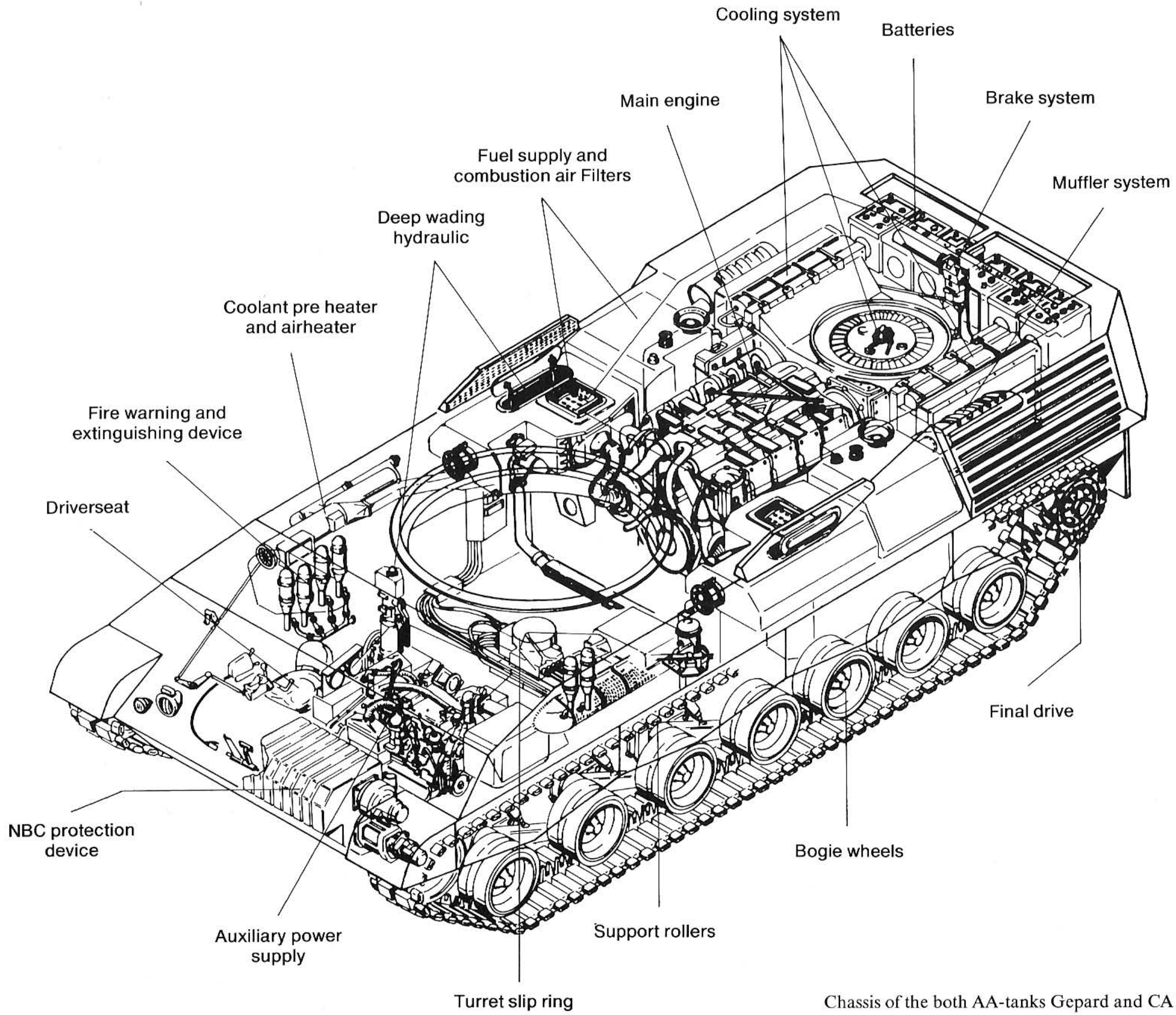
The Diesel engine driven, power supply is installed at the forward left side of the vehicle hull. It is the power generated by this equipment which is used to drive the fire control and weapon system

Auxiliary Power Supply Installation.





Both the turret and weapon drives require large, widely fluctuating supplies of DC power. Two high output DC generators (Metadynes) provide this.



Chassis of the both AA-tanks Gepard and CA1

generators. In all, a total power requirement of 50 kW is necessary. Also stowed within the vehicle hull is the FNA-4 Terrestial Navigator Unit which is manufactured by the Teldix Company. This Terrestrial Navigator is used for terrain orientation, local air space display and establishing the North for setting, both surveillance radar and display.

In April 1972, the decision was made that the Siemens-Albis monopulse doppler fire control system which was to be used in the system shoüld be placed into series production. Whereby, steps were to be taken to facilitate the later installation of a laser range finder also manufactured by Siemens.

Contraves, on November 12th, 1973, established a collective list of 35 mm Anti-Aircraft Weapon System designations:

1. The composition of these designations was established by using an alphanumeric/numeric combination, the alphanumeric code determining the development stage or radar system involved. The numerical code permitting identification of the individual equipment.

1.1 *Development phase designations*

a) Federal Republic of Germany	
1st generation prototype	A
2nd generation prototype	B
pre-series (conical scan)	B
pre-series (optimised monopulse)	B2R
1st series lot	B2
series vehicles with laser range finder	B2L
b) Holland	
prototype	C
pre-series	CA
series	CA1

1.2 *Weapon system numbering*

All of the weapon system numbers began with 35 (for 35 mm caliber) and were extended as follows:

prototypes	3 digit	(351–357)
pre-series	4 digit	(3501–3517)
series	5 digit	(35001 onwards)

1.3 *Radar systems employed*

			Band
"A"	surveillance radar	HSA: MTI	X
	tracking radar	SAZ: frequency diversity	KU
"B"	surveillance radar	SAZ: MPDR 12	5
"B 1"	surveillance radar	SAG: MPDR 12	5
	tracking radar	SAZ: pulse doppler conical scan	KU
"B2R"	surveillance radar	SAG: MPDR 12	5
	tracking radar	SAZ: pulse doppler monopulse	KU
"B 2"	surveillance radar	SAG: MPDR 12 optimised	5
	tracking radar	SAZ: pulse doppler monopulse	KU
"C"	surveillance radar	HSA: integrated MTI system	X
	tracking radar	HSA: integrated pulse doppler system	X
"CA" and "CA 1"	surveillance radar	HSA: integrated MTI system using modular type construction	X
	tracking radar	HSA: integrated system using modular type construction, pulse doppler	X
		pulse	Ka

HSA = Hollandse Signaalapparaten, SAG = Siemens AG, SAZ = Siemens-Albis Werk, Zürich.

2. Weapon system designations

	Federal Republic of Germany	Holland
Prototypes (PT)	A 351 to A 352 B 352 to B 356	C 357
Pre-series (PS)	B 1-3507 to B 1-3506 B 2 R-3507 to B 2 R-3512	CA-3513 to CA-3517
Series (S)	B 2-35001 onwards	CA-35001 onwards

3. Chassis Numbers – Countries

Federal Republic of Germany	35001–35420
Holland	35501–35595
Belgium	35601–35655

5.5.3.3 Series "GEPARD" Anti-Aircraft Tanks

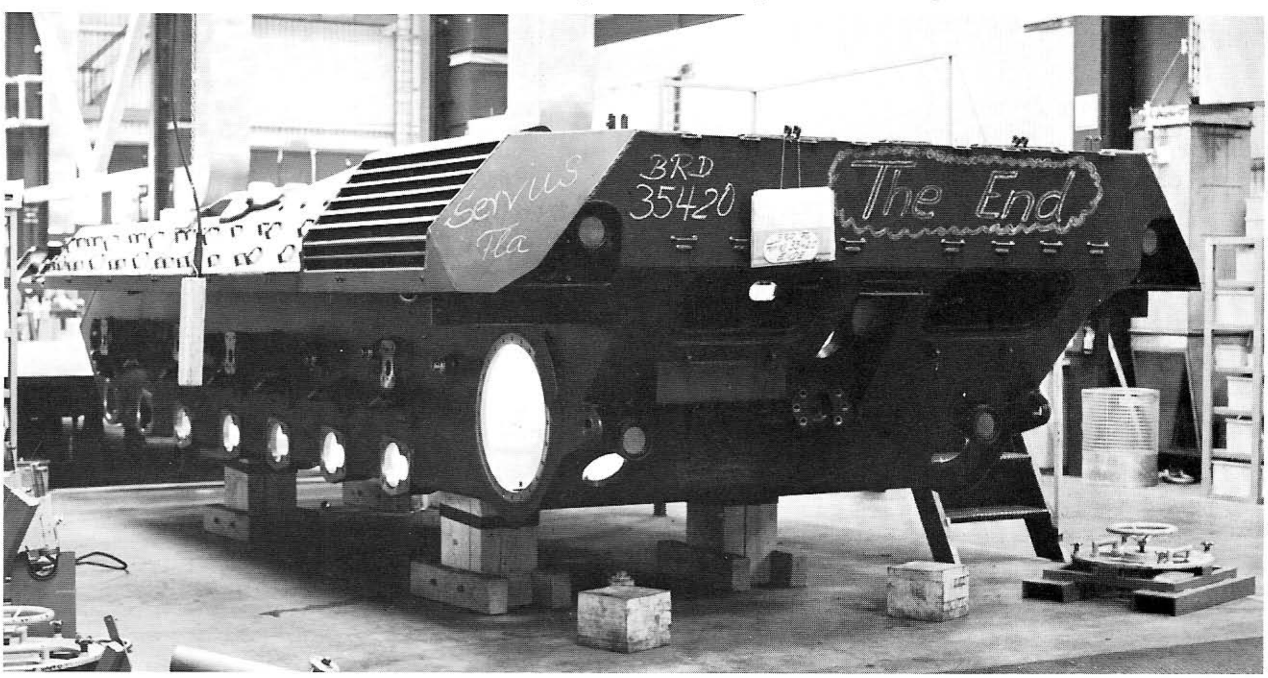
On February 5th, 1973, the Ordnance Department of the German Ministry of Defense announced that the 5PFZ, Type B version of the 35 mm anti-aircrafts tank was to be procured in quantity and introduced into service with the Army. Krauss-Maffei AG were appointed General Contractors. Oerlikon-Contraves co-operating with authorised sub-contractors were to assume total system and pre-production responsibilities. For manufacturing sub-systems in the Federal Republic of Germany, Siemens AG were to produce the fire control system, Wegmann Co. the turret and weapon systems and Krauss-Maffei the chassis. Oerlikon Machine Tools were to make partial deliveries of both weapons and auxiliary equipment, Contraves were to manufacture and supply fire control components.

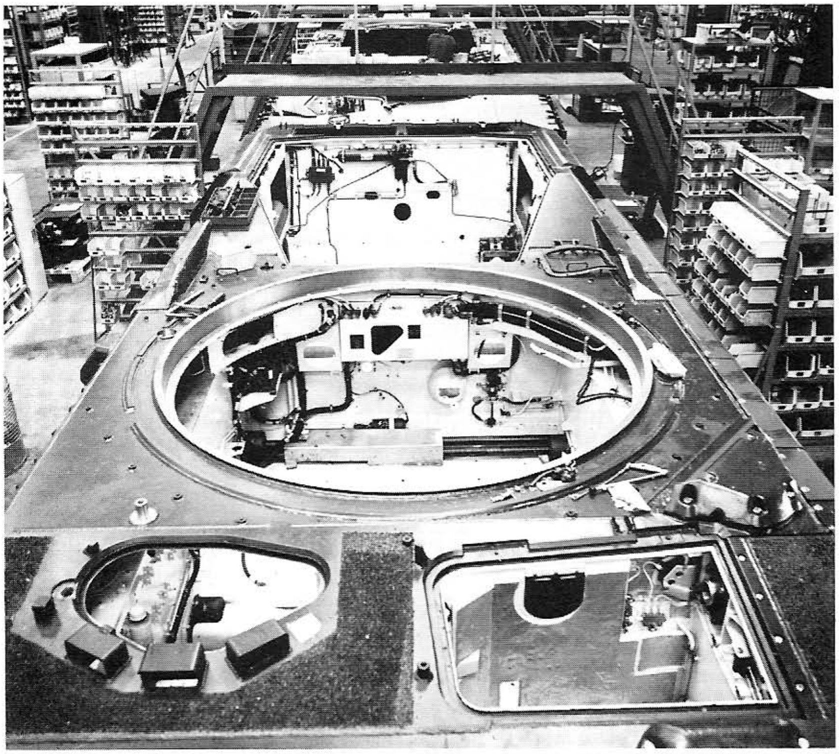
In Juni 1973, the Procurement Agency (BWB) established the requirement that the first series anti-aircraft tanks were to be delivered in 1976. A total of twenty vehicles was requested, divided into two production lots the first lot consisting of twelve systems, the second of eight. Due to the pre-production planning schedule which Oerlikon-Contraves had already defined, such deliveries could only be met when six of the vehicles in question were integrated by Oerlikon-Contraves themselves. In order to avoid any delay in commencing series production mid-1976, the 20 sets of sub-assemblies needed were to be of Swiss manufacture, the balance thereafter being manufactured under licence in the Federal Republic of Germany.

In September 1973, the German Armed Forces officially christened the anti-aircraft tank with the name "GEPARD".

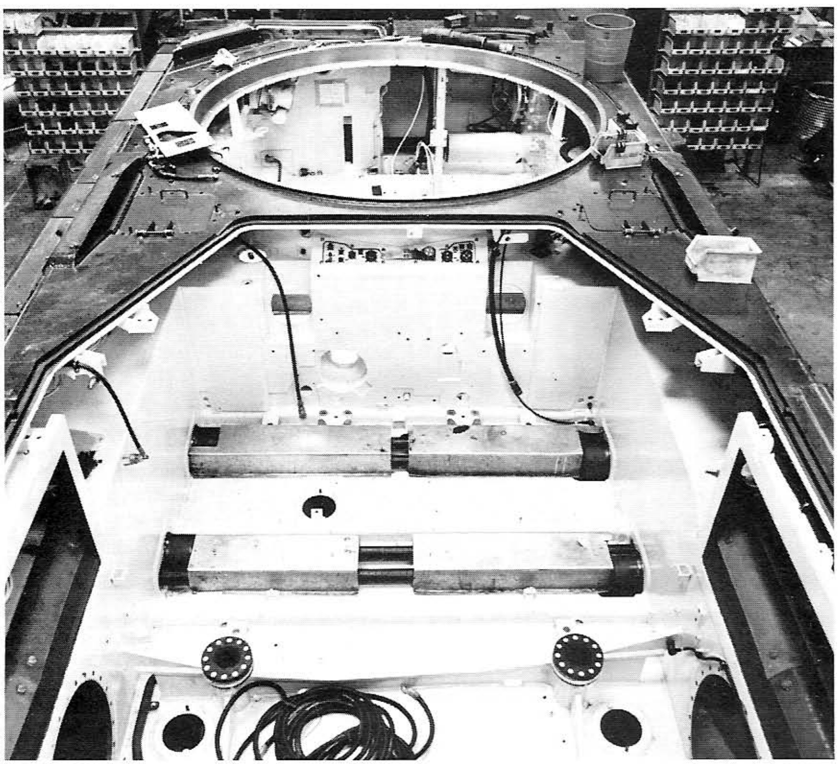
Due to various delays which occurred during Oerlikon-Contraves's pre-production planning phase, the participating industries presented a new delivery schedule for consideration which indicated delivery of the first series systems for December 1976. Furthermore, this new schedule indicated that the six systems to be directly delivered by

A-A Tank Assembly by Krauss-Maffei. The last hull prior to it's being sent down the production line.



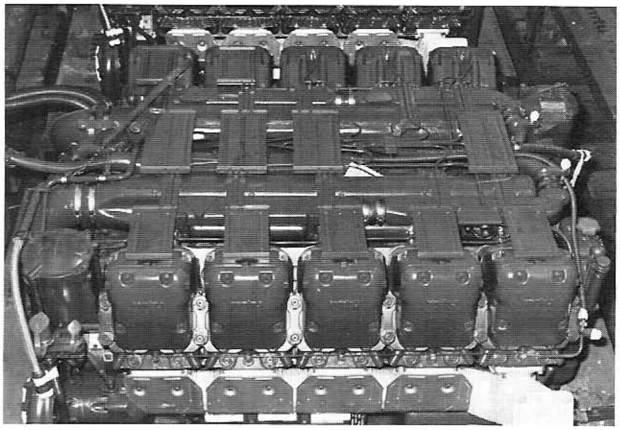


A-A Tank hull details. Forward of the turret ring on the left is the driver's hatch, on the right the Auxiliary Power Supply compartment.

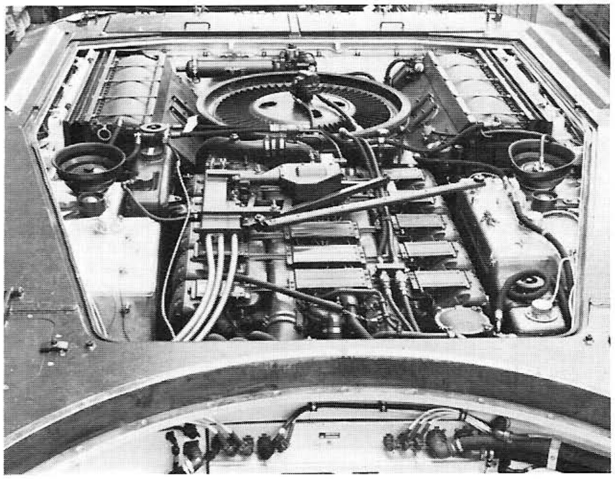


A rear view of the hull showing the engine compartment. The transversely positioned torsion bars are partially covered.

MTU-Motor, Type MB 838 CaM 500 with 610 kW (830 PS) Output.

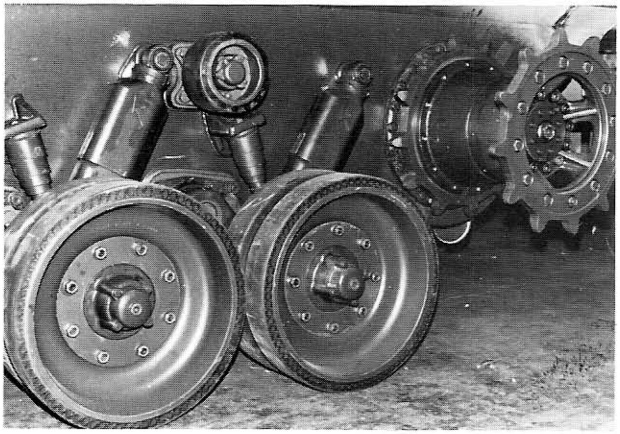


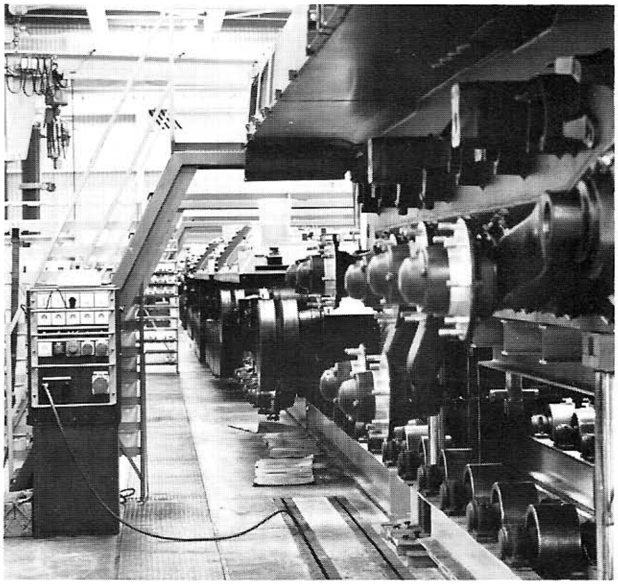
The power pack is installed, in the foreground on each side are the fuel tanks.

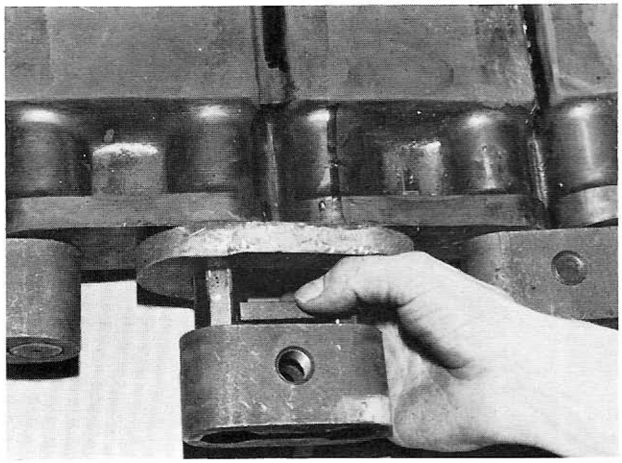


Bottom Right: Chassis Assembly Line on which the Leopard 2 MBT Chassis can also be assembled (Vehicle in foreground).

Part of the assembled Gepard A-A Tanks running gear. Alongside the drive sprocket are the road wheels, the bump stops for the road wheels suspension arms and a support roller.



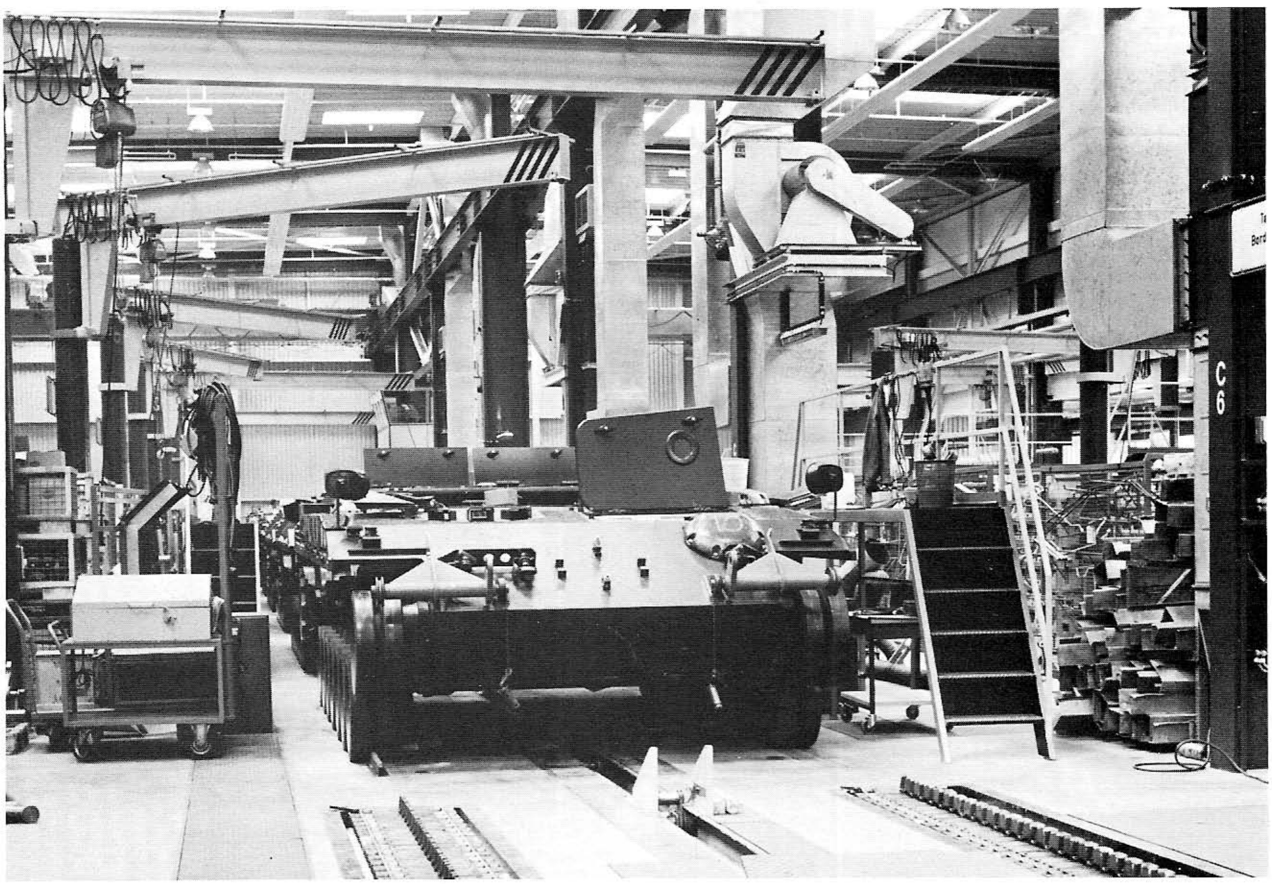




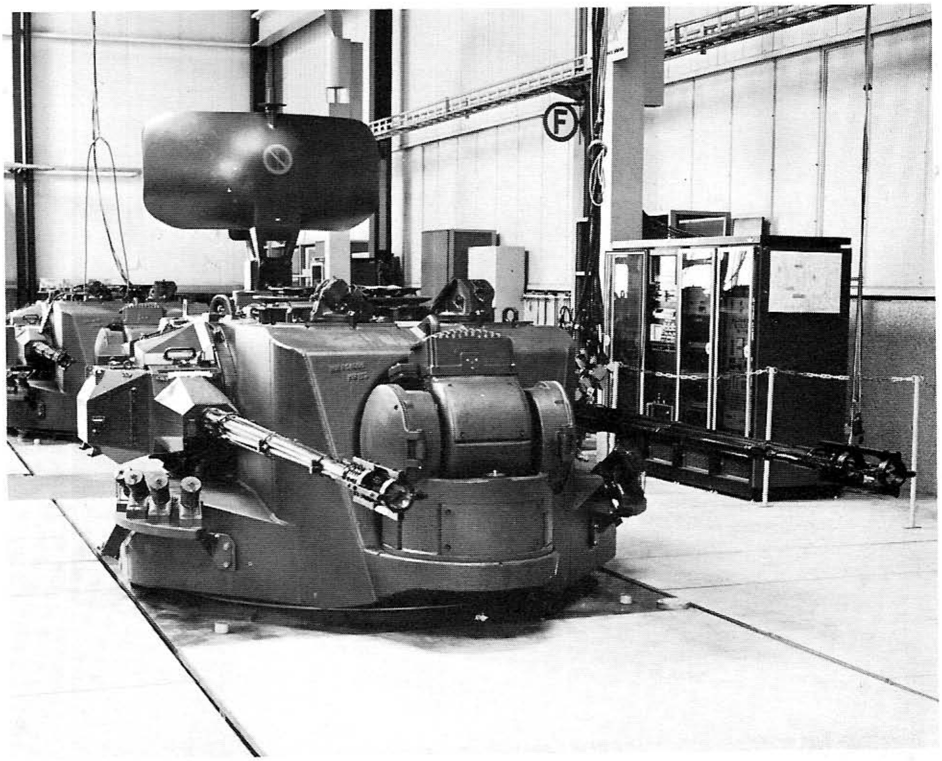
The A-A Tanks Track Connector Link.

Exhaust grating of both Gepard and CA 1 A-A Tanks.

The completed hull/chassis of the end of the assembly line prior to the tracks being fitted.



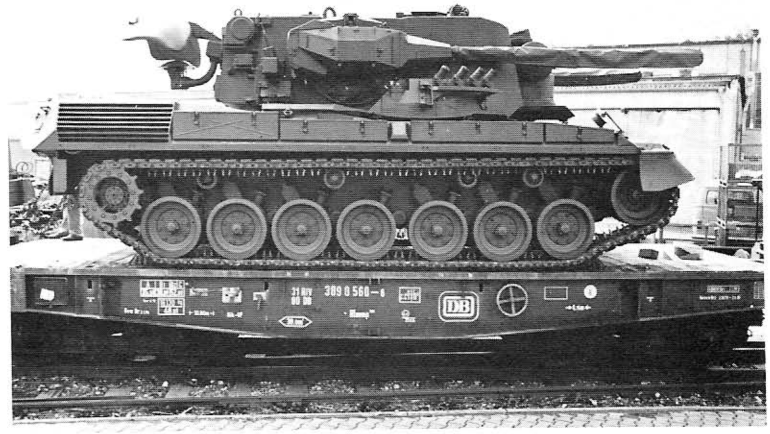
In the Integration Hall, turrets delivered by the Wegmann Co. were received by Krauss-Maffei.



The turret is mounted on it's chassis and begins final acceptance testing.

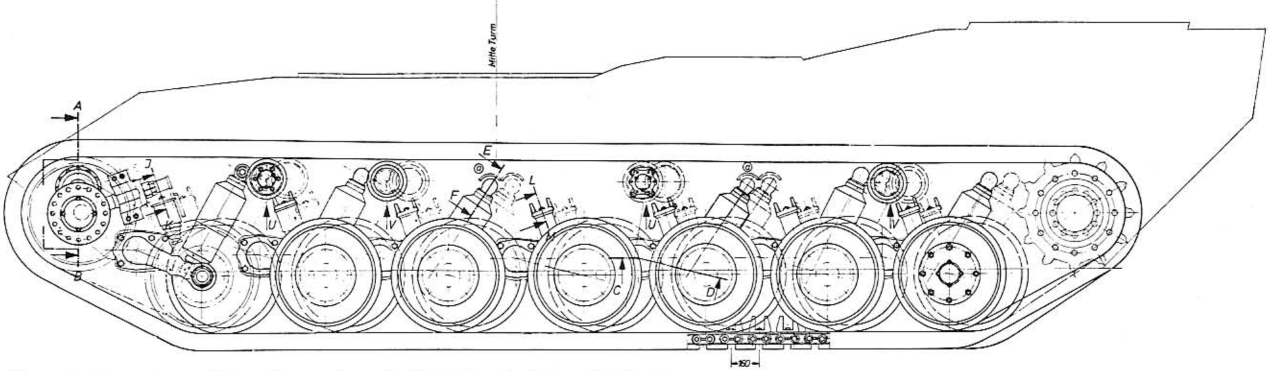
Two views through the Krauss-Maffei Integration Hall.

Gepard A-A Tank being loaded on a railway flat cars for transport to the Army.



The current production program of Krauss-Maffei's Ordnance Division. From left to right, Gepard A-A Tank, Leopard 1 MBT, Leopard 2 MBT (1980).

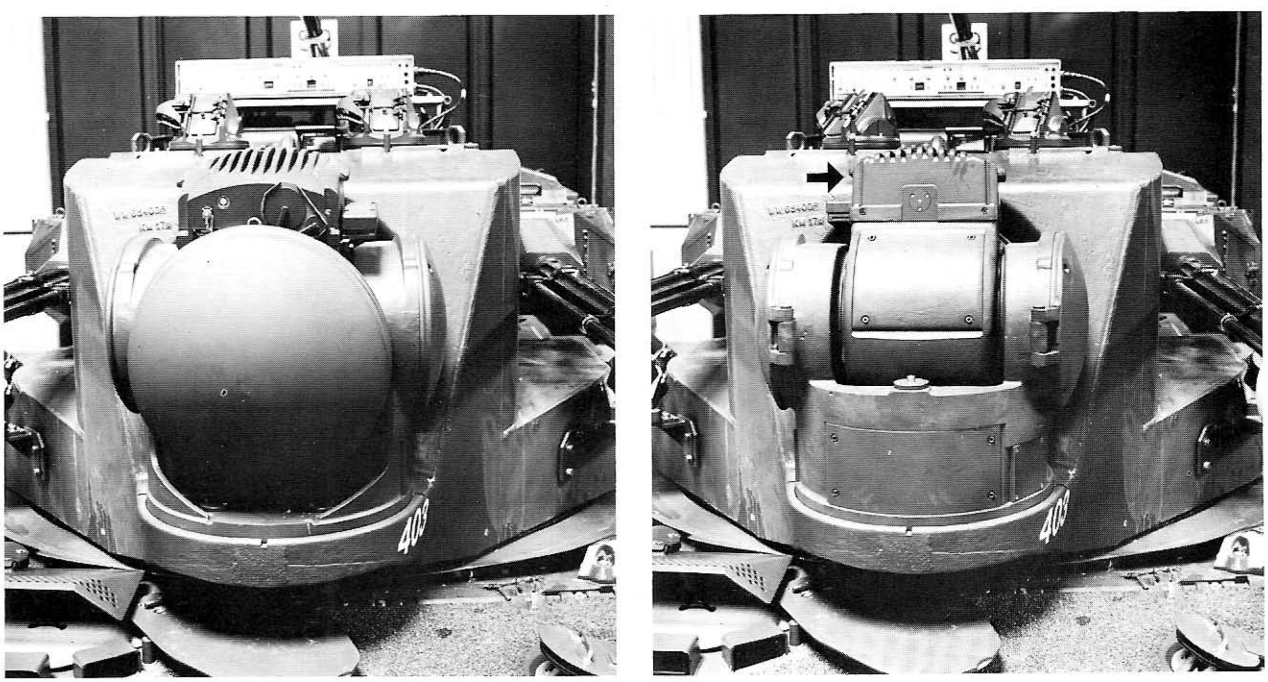
The Gepard A-A Tank complete with it's full complement of ammunition.

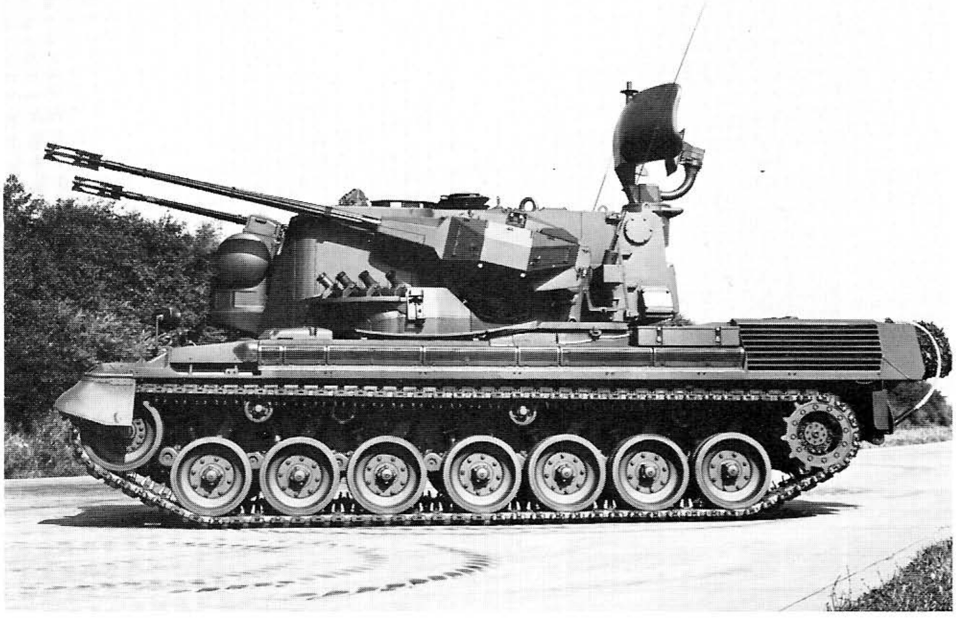


Chassis Drawing of the Gepard and CA 1 Anti-Aircraft Tanks.

Oerlikon-Contraves would be available between December 1976 and April 1977. Integration in Germany by Krauss-Maffei was planned to commence in May 1977. Actually, in 1977 sixty-two "Gepard" anti-aircraft tanks were delivered.
The delivery contract, concluded on May 23 1973 between the Federal Procurement Agency (BWB) and Krauss-Maffei which covered 122 AA-tanks, type B 1 was followed up to 1979 by amendments to the contract, including the delivery of a total of 420 AA-tanks, type B 2 (March 1975), altered in June of 1979 for the final delivery of 195 AA-tanks, type B 2 and 225 AA-tanks, type B 2 L with Laser range finders. On December 16th, 1976, the first of the series-produced AA-tanks was officially handed over to the Bundeswehr, the last on October 29th, 1980.
In the meantime, the weapon system Gepard has proved itself as being the most effective divisional air defense weapon of the Bundeswehr. Groups of thirty six weapon systems provide the core of each air defense regiment.

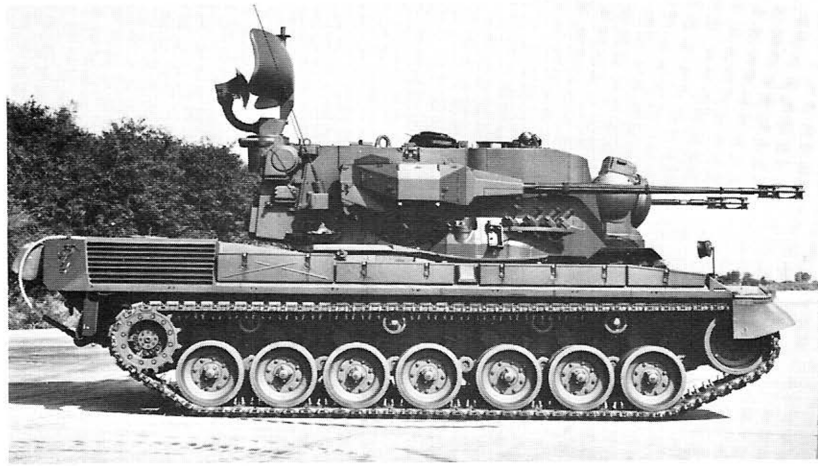
Series Gepard, Type B2L vehicle with Laser Range Finder. Photograph on the left shows the front view, on the right rotated through 180° (see arrow)



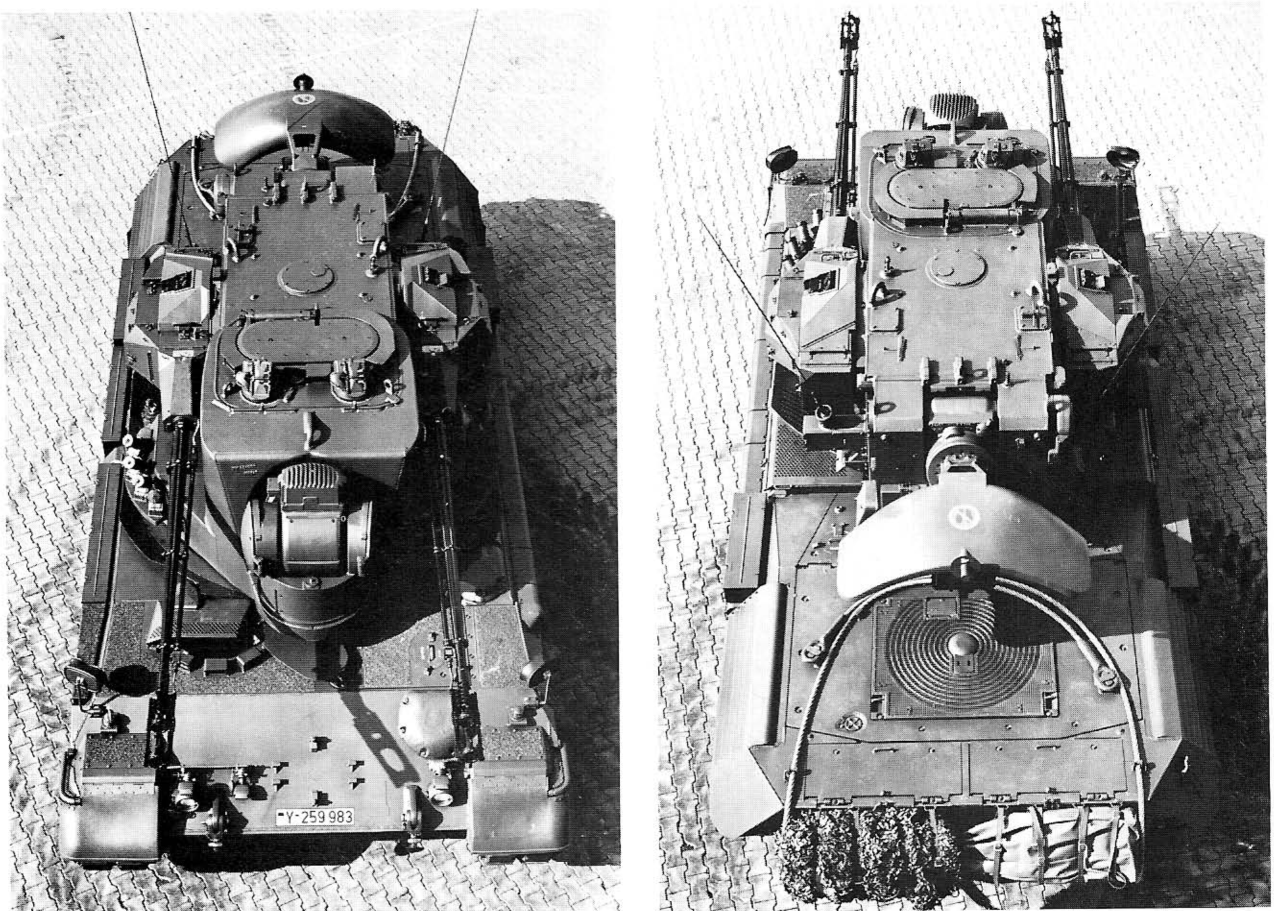


Gepard Anti-Aircraft Tank in the Krauss-Maffei Testing area, shown above, before a radome containing final calibration equipment for the Surveillance and Tracking Radars. Below the vehicle is shown on the test track with both radars at the ready position.

Three views of the Gepard Anti-Aircraft Tank as delivered to the German and Belgian Armies.

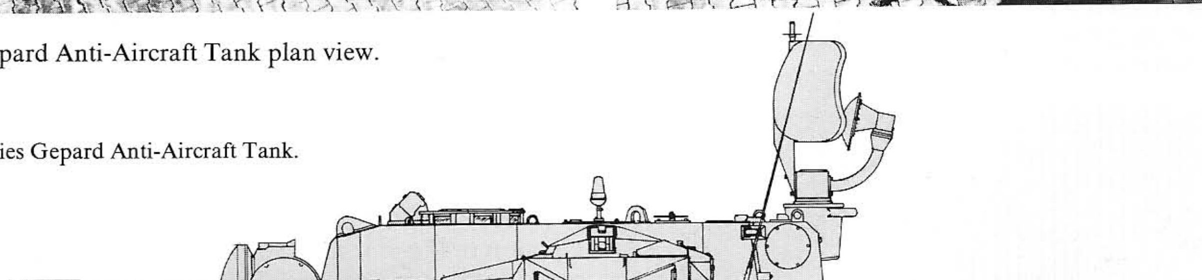


Front and Rear Views of the Gepard Anti-Aircraft Tank.



Gepard Anti-Aircraft Tank plan view.

Series Gepard Anti-Aircraft Tank.



5.5.3.4 Anti-aircraft-tanks, type B 2 for the Royal Belgium Army

In April 1973, the first intensive discussion between representatives of the Belgian Ministry of Defense and German Industry took place concerning delivery of fifty five anti-aircraft tanks.

Two views looking down on the 5 PFZ-C Prototype Anti-Aircraft Tank equipped with Dutch Radar Equipment. An O-Series Leopard MBT Chassis is being used as system carrier.

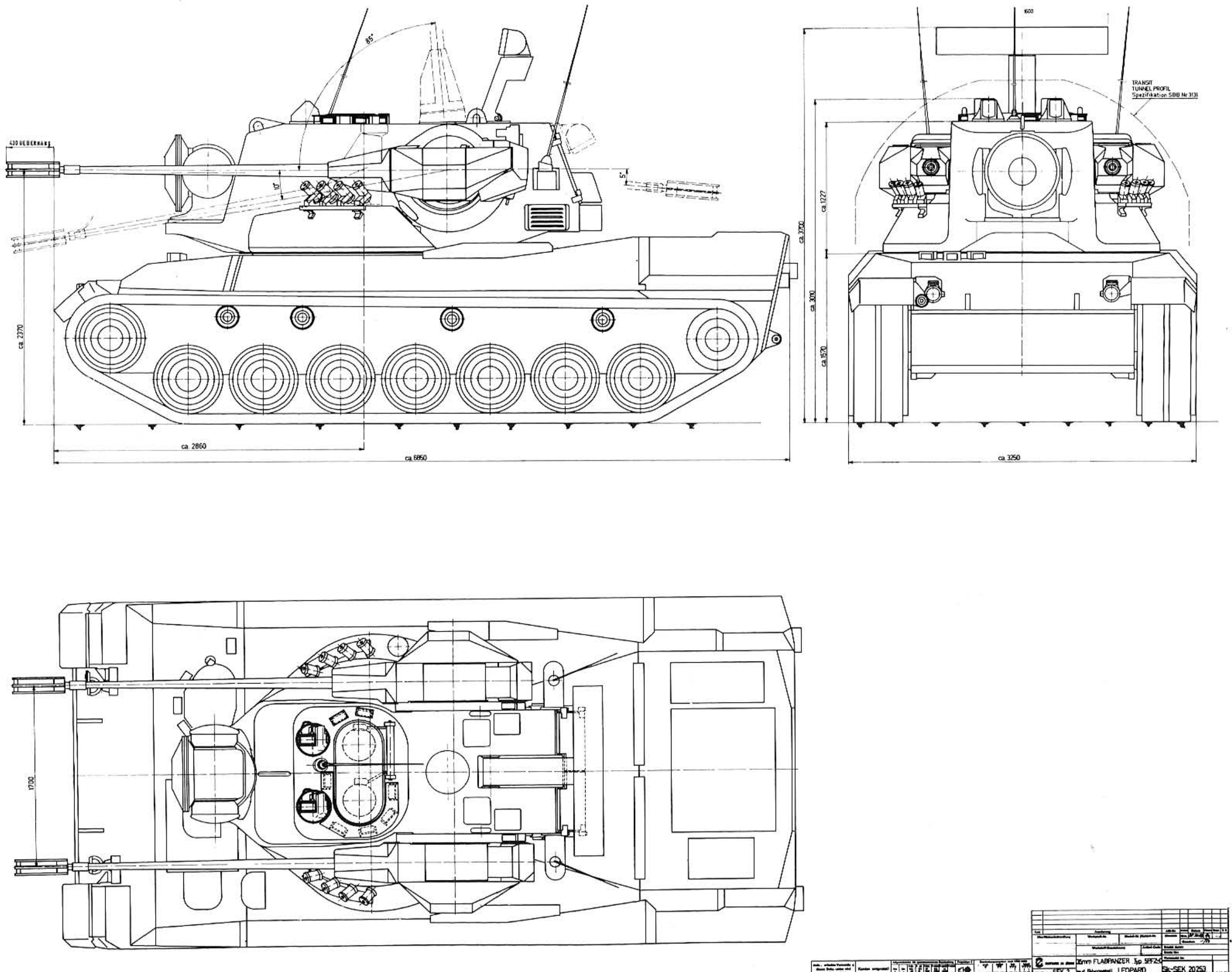
Due to the far reaching effects of the co-production offer made by the Siemens Company and the very favorable procurement costs in comparison to the CA1 system, Belgium selected the B 2 version of the Gepard for procurement. On 21st May, 1973, Krauss-Maffei presented their tender for the delivery of fifty five type B 2 Gepard anti-aircraft tanks which led to the Belgian Government signing a letter of intent on 19th December, 1973. The final contract being signed on the 4th April, 1974, delivery to the Belgian Army commenced at the end of 1977 and was completed in February 1980. Of the fifty five systems ordered, twenty seven were of the B configuration and twenty seven were of the B 2 LV configuration (LV = prepared for Laser Range Finder installation). The remaining (55th) system was not assembled as its components were required for training purposes. The B 2 series vehicles of the Belgian Army are identical to the B 2 series vehicles of the Bundeswehr.

Belgian personnel had been present during the system trials at the Bundeswehr trials facilities from the very beginning.

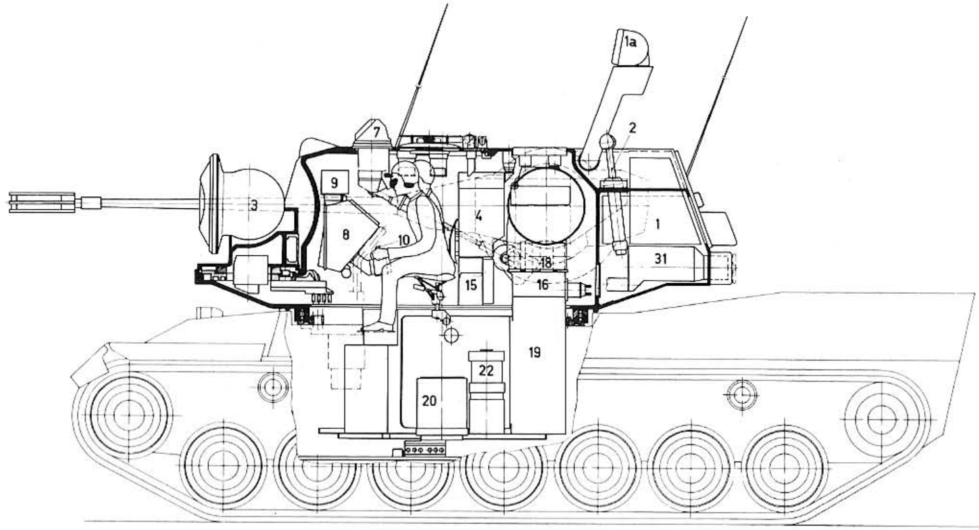
Both Belgian and Dutch industry were involved in the production of the Belgian A-A Tanks due to extensive and comprehensive compensation and co-production agreements.

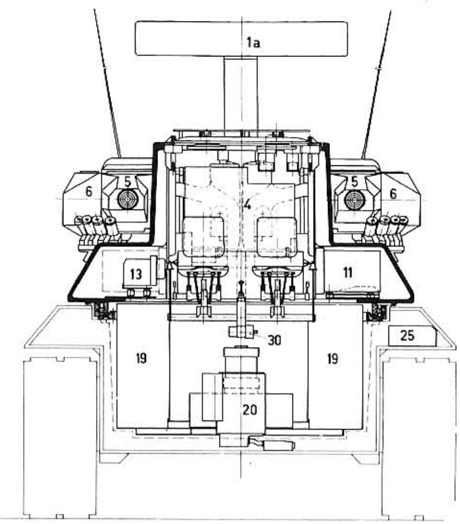
5.5.3.5 Prototype Anti-Aircraft tank 5 PFZ-C, Pre-Series tanks CA and CA-1 Anti-Aircraft Tanks for the Royal Netherlands Army

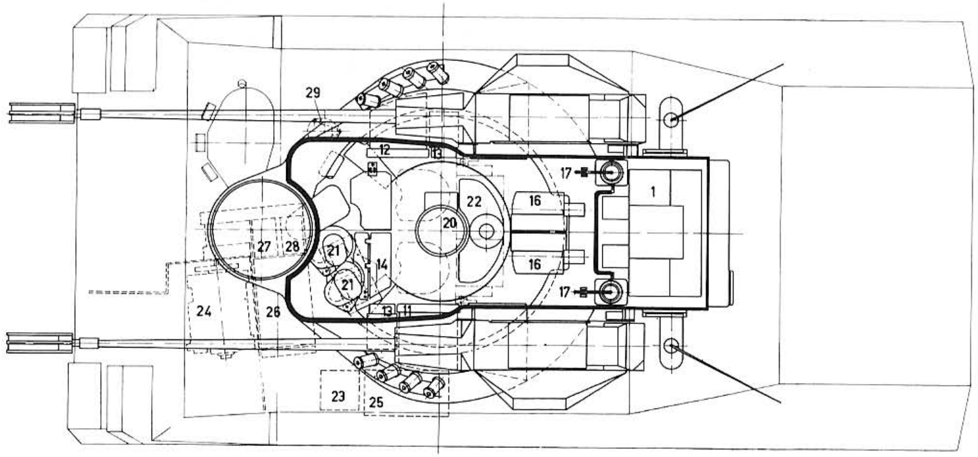
June 7th, 1967, found the Dutch military authorities discussing the possibilities of their joint participation in the anti-aircraft tank development program with the German Ministry of Defense. Following these discussions, on August 14th, 1967, Hollandse Signaal Apparaten (HSA), a subsidiary of the Philips Concern, presented their integrated electronics concept for the anti-aircraft tank. This concept proposed that the two separate radars and differing frequency bands (S and K_u) as realised in both the B and B 2 anti-aircraft tanks be replaced by only one radar transmitter operating in the X-band. By means of a power divider this radar could then be applied for both the surveillance and tracking/fire control radars.



Prototype 5 PFZ-C Anti-Aircraft Tank in all three elevations.







1 Suchradar - Sender / Empfänger, IFF-Gerät
1a Suchradar - & IFF-Antenne
2 Hubwerk zu Suchantenne
3 Zielfolgeradar - Richtgerät mit Antennenaggregat
4 Radar - Auswerteelektronik
5 35mm Gurtkanonen
6 Behälter für Spezialmunition
7 Periskope
8 Taktischer Anzeige- & Bedienungsteil
9 IFF-Bedienungsteil
10 Steuerknüppel
11 Anlageelektronik, Logik
12 Steuerung ZR, Schützenkasten
13 Funk-Empfänger
14 Funk-Sender / Empfänger
15 Rechengerät
16 Munitionskanäle mit Booster
17 Geschütz - Höhenausgleicher
18 Geschützantrieb
19 Behälter für Flabmunition
20 Turmschleifring
21 Turm - Seitenantrieb
22 Hydraulik - Anlage
23 Elektronik für Metadyn-Steuerung
24 Zusatzmotor
25 Statischer Umformer
26 Metadyn - Generator
27 380 Hz - Generator
28 Lademaschine
29 Verkantungsmessgerät
30 Notabzug
31 Wärmeaustauscher

35mm Flabpanzer Typ 5PFZ-C auf Fahrgestell LEOPARD SK-MEK 20301

Longditudinal and Cross-Sections of the 5 PFZ-C Anti-Aircraft Tank Prototype.

Side view of a prototype 5 PFZ-C Anti-Aircraft Tank of the Royal Netherlands Army in firing position (above) and in march position (below).

In 1968, in agreement with the German Ministry of Defense, the Netherlands ordered a prototype designated 5 PFZ-C from Oerlikon-Contraves. This variant included the integrated surveillance and tracking radars as previously proposed by HSA. It was also suggested that this variant be equipped with the Siemens MRS 400 IFF (Friend/Foe) interrogation unit. On March 18th, 1968, Oerlikon-Contraves suggested a basic turret configuration change in order to avoid the rather ungainly mounting of the HSA integrated radar equipment on the turret bustle.

In October 1968, the Director of the Department of the German Ministry of Defense charged the Dutch Quarter Master General with the authority to purchase a prototype anti-aircraft tank complete with integrated HSA electronics.

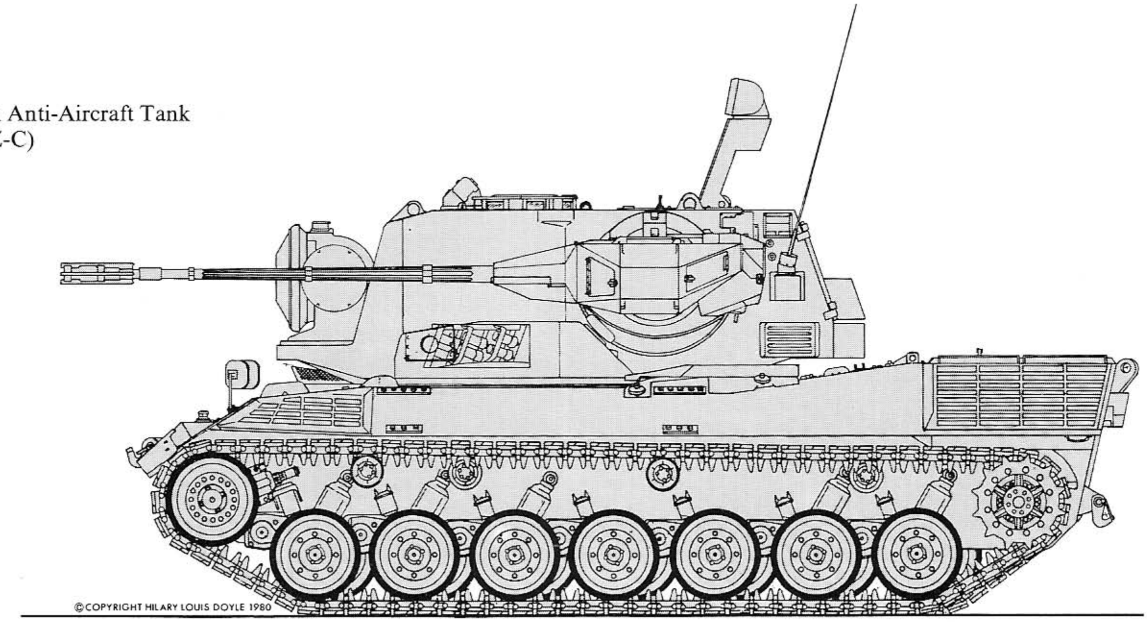
At the request of the Dutch Government, Department KG II 1 of the German Procurement Agency (BWB) ordered on March 28th, 1969, from Krauss-Maffei AG the modification of the Leopard O-series chassis number J-0-16. This modified chassis was then handed over to Oerlikon-Contraves on March 11th, 1970. The completed prototype began its trials in spring of 1971, with Dutch personnel participating. These intensive trials were carried out at two of the German military proving grounds, Facility No. 81 (radio and electronics) and Facility No. 91 (weapons and ammunition).

Following this, the Dutch Government ordered in 1971 from Oerlikon-Contraves five pre-series anti-aircraft tanks which received the designation CA, the necessary chassis for these vehicles were supplied by Krauss-Maffei. On April 10th, 1972, both Krauss-Maffei and Oerlikon-Contraves received requests for quotation from the Dutch Authorities for the delivery of ninety five CA1 anti-aircraft tanks. In response, Krauss-Maffei submitted their tender on June 28th, 1972. After lengthy negotiations Oerlikon-Contraves and Krauss-Maffei jointly informed the Dutch Government on April 17th, 1973, that Krauss-Maffei alone would carry out the contract in question. This decision led to Krauss-Maffei submitting a new tender for the Dutch Government's consideration on April 18th, 1973. In response to their tender of April 26th 1973 Krauss-Maffei received a letter-of-intent for the delivery of ninety five CA 1 anti-aircraft tanks from the Dutch Government. This date was in fact earlier than Krauss-Maffei's receipt of a contract from the Federal German Government for the Gepard anti-aircraft tank.
On January 24th, 1974, a contract followed for the delivery of sixty CA 1 anti-aircraft tanks together

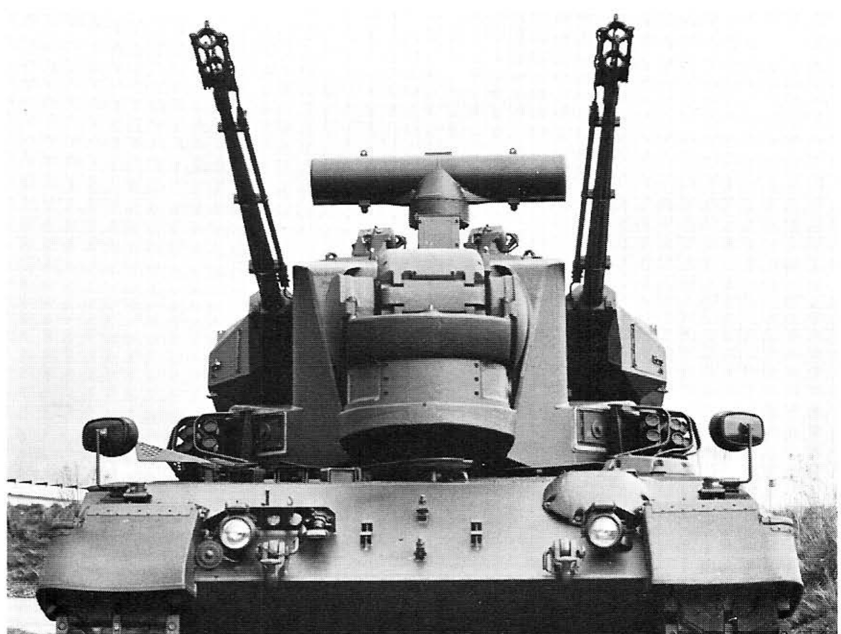
The Tracking Radar located between the Twin 35 mm Cannon is easily discernable.

Prototype 5 PFZ-C Anti-Aircraft Tank with radar antennas and weapons in the "locked" positions.

Twin 35 mm Anti-Aircraft Tank
(Type 5 PFZ-C)

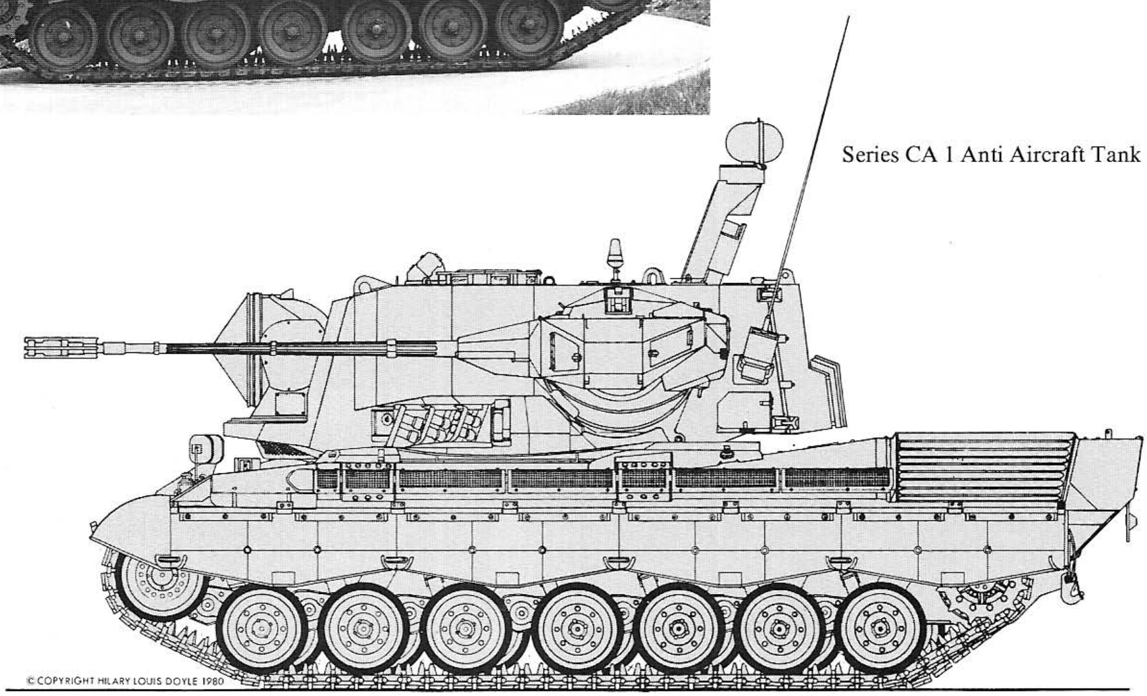


Frontal view of a Dutch Army Series CA 1 Anti-Aircraft Tank. For logistical reasons the original, Type 139 E Tracks are fitted. Besides the Radar System, the Smoke Grenade Launchers are also of Dutch design.



with an option for further thirty five systems, this option was taken up on November 11th, 1974. Oerlikon-Contraves were commissioned once more with the pre-production planning responsibilities for the CA 1 A-A Tank. The first five CA 1 A-A Tanks were handed over to the Dutch Army at the end of 1977. Delivery of the complete CA 1 series closed in December 1979.

CA 1 Anti-Aircraft Tank Series Model, viewed from each side. In contrast to the Gepard the Dutch vehicles were ex-works fitted with Track Skirts.



Series CA 1 Anti Aircraft Tank

*5.5.3.6 System Peripheral Equipment of the "GEPARD" Air Defense System**

Currently the German Army has in service weapon systems which are more complex than any of those previously in service. These systems consist not only of the systems themselves, but also of the Peripheral Equipments required by them. These peripherals cover all the various needs including Training, Maintainance, Repair, Technical/Logistical Documentation and Spare Parts supply.

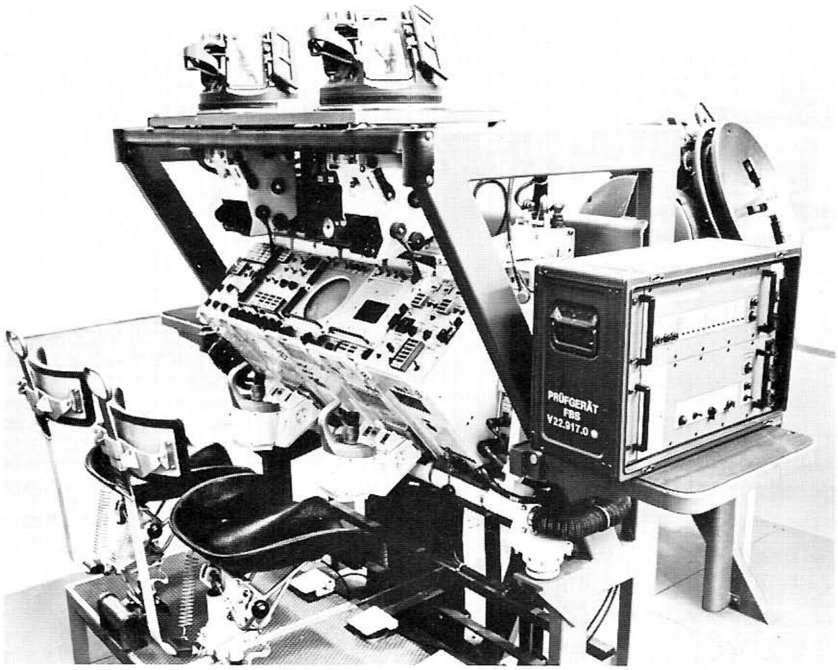
The "Total System Concept" must be applied today from the beginning of any modern weapon system development project. It is only by such consequential consideration of the necessary peripheral equipment being developed that enable a weapon system to be maintained to provide maximum performance continually. It is only by ensuring the timely development of such peripherals which enable the logistical maturity of a weapon system being established quickly. Only logistically mature weapon systems are able to meet and maintain the standards of reliability and combat readiness which are expected of them today.

Furthermore, an extremely important part of the logistical maturity of any system includes training of both crews and maintenance personnel, adequately supported by the necessary Technical/Logistical Documentation, Spare Parts, Workshops and their rich assortment of test equipments.

Crew Training
GEPARD crew training for the individual German AA regiments is centralised, and is carried out by the Army Air Defense School. Service and maintenance personnel also attend the basic training courses to learn how the GEPARD and its equipment function. To reduce the amount of

*** Author Joachim Mayer, Krauss-Maffei AG.**

Training facility AA-tank for commander and gunner



Training facility for maintenance crew

time necessary for training, the GEPARD basic training simulator is used and enables the simultaneous training of twelve student crews. The simulator is designed to facilitate either individual or group training. In the case of the former, the commander or gunner is trained, with the role of the absent crew member being taken over by the computer.

Basic training includes familiarization with and correct operation of eighty control and indicator elements contained on the five control panels, plus the two joy-sticks. Students learn the correct sequential operation of the controls as indicated by means of LEDs (Light Emitting Diodes). The computer is programmed so that the time interval between the illumination of any two indicators can be varied as desired. This enables operation of the controls to be adjusted to suit learning ability of the various students. As students progress, the training program is changed, indicators illuminate to indicate to the students only when they have incorrectly operated the controls.

Fighting Compartment Simulator

On successful completion of the course on the basic training simulator, which also includes facilities for periscopic sight training, students then progress to the Fighting Compartment Simulator. This stationary rig is an independent unit with stations for two trainees and an instructor. It can simulate simplified engagement procedures with the instructor monitoring and assessing the crew's activities both visually and by means of displays and data print-outs. The instructor is also able to feed information into the fighting compartment displays. It is then left to the crew to assess the AA tank's operational readiness, the tactical air situation, and to report their intended actions optically and acoustically by operating the appropriate controls.

Air target Simulator

To make crew training more realistic, the fighting compartment of an actual GEPARD AA tank is employed together with the air target simulator. With all hatches closed the simulated conditions are extremely lifelike. The video displays (all-round surveillance radar, periscope sights, and B-scope) can be used to simulate up to three independent air and/or ground targets which can be selected at will. Both the target and its background can be represented on the periscopic sight display.

In addition, each air target can identify itself as friendly or hostile, (IFF) simulation. The air target simulator makes it possible to enact complete engagements from target detection on the surveillance radar screen to the point of readiness to open fire. Realistic manœuvers can be simulated, including the surprise appearance of an air or ground target, or multiple and diversion attacks. ECM can also be simulated, as well as the adoption of ECCM. The various combat situations are controlled by programs stored on magnetic tape. Terminal training of GEPARD crews also incorporates participation in realistic manœuvers and firing exercises.

Maintenance Personnel Training
In order to achieve rapid, effective maintenance to the level required by the military authorities, selected military personnel are given specially developed courses of instruction by both military and civilian system specialists. Practice rigs to facilitate training are available for the electronics, power supply equipment and weapons, all of which use original GEPARD sub-assemblies and components. The practice rigs are used in conjunction with the original workshop equipment used for normal GEPARD maintenance and repair, thus test equipment can be directly connected to the respective practice rigs.

The electronics repair practice rig covers all the fire-control system sub-assemblies and those parts of the vehicle's terrestrial navigator housed in the chassis. This rig can be run as a fully operational unit while other parameters such as turret and weapon control, muzzle velocity, vehicle speed, and navigator/tank rotation are simulated. A digital processor assumes control of the safety circuits, the simulation procedures and input of simulated malfunctions into the fire-control system enable the instructor to gradually increase the degree of complexity of malfunctions with which the trainees have to deal with. Eventually, more complicated malfunctions are simulated.

The weapon repair practice rig consists of the weapon itself, its associated hydraulics, the muzzle velocity measurement system, and the weapon electronics. Its purpose is to train repair technicians on the weapon (including the muzzle velocity measurement system) and on the weapon hydraulics and electronics.

The power supply repair practice rig embraces all the sub-assemblies, both of GEPARD's electrical systems and turret and weapon aiming systems. The rig includes load, base-load, turret and weapon-load simulators, a bearing and elevation balancing simulator, supply equipment and weapon controls simulator. It allows all repair work on the power supply and the turret and weapon aiming systems to be practiced.

Technical/Logistical Documentation
Comprehensive technical/logistical documentation is available for training, maintenance, repair, calibration, and spare parts supply. This documentation covers the various peripheral equipment as well as the GEPARD tank.

The important maintenance and repair activities together with their relationship to the individual maintenance phases are described and set in the technical documentation. Thus the following activities are to be carried out in the stages as prescribed below:

Maintenance Level 1 a (routine maintenance and care by the vehicle crew)

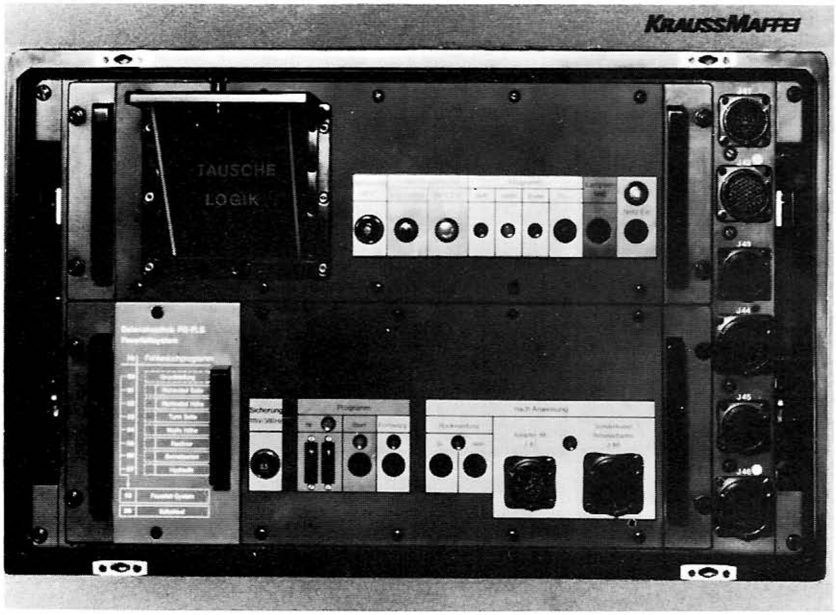
Maintenance Level 2 (troop maintenance/repair by regimental/battalion maintenance personnel)

Maintenance Level 3 (field maintenance/repair by brigade and divisonal maintenance personnel)

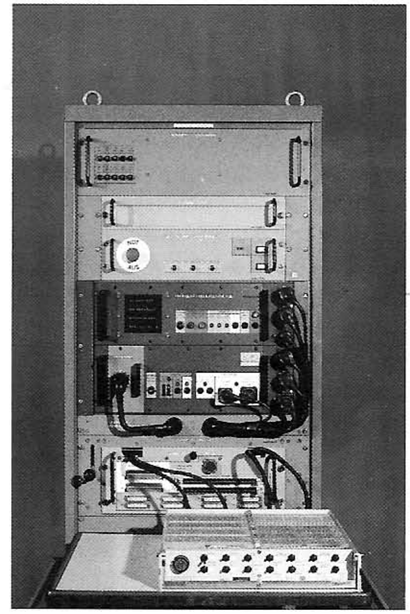
Maintenance Level 4 (overhaul and repair of sub-assemblies by industry)

Maintenance Level 5 (major overhaul and repair by manufacturer at manufacturer's premises)

For easier use, the Technical Service Manuals have been divided into two main groups, a and b:
a) Fire control System and Weapons (TSM Nr. 1010/011)
   Part 31. Catalogue of Maintenance Echelon Levels



Universal programed testing device



Test bench for Sub-Assembly Repair

Part 10. Equipment Descriptions
Part 20. Operation and Care
Part 22. Maintenance Regulations/Service Intervals
Part 32. Adjustment
Part 30. Maintenance and Repairs 2nd Echelon Level
Part 40. Maintenance and Repairs 3rd Echelon Level Contact Teams

b) Chassis/Hull, Auxiliary Power. Unit and Main Power Pack (TSM Nr. 2350/26)
Part 31. Catalogue of Maintenance Echelon Levels
Part 12. Equipment Descriptions with Operating Instructions and Care
Part 22. Maintenance Regulations/Service Intervals
Part 30. Maintenance and Repair 2nd Echelon Level
Part 40. Maintenance and Repair 3rd Echelon Level.

Spare Parts
The next phase is that of determining which initial spare parts should be acquired when setting up a spare parts stock. It is with this in mind that the General Contractor has guaranteed the delivery of the necessary spare parts for the next ten years.

Supplementary to the Technical Service Manuals, separate conservation and packaging instructions are issued. For all spare parts these packaging conservation regulations must be strictly observed as this considerably extends the "shelf life" of these parts.

Maintenance and Repair
The largest and most important part of achieving logistical maturity involves the peripheral equipment and ancillery facilities for maintenance and repair at all levels. For this requirement fully equipped mobile and base workshops have been developed.

Maintenance and repair teams are divided into the following four specialist groups:
Electronics, Weapons/Hydraulics/Power Supply, Automotive Equipment, plus supplementary GEPARD special parts, which are stowed together in the Leopard workshops.
Workshop equipment is grouped and stored according to its specialist area. These are then com-

bined to form the various mobile workshops and cover eight groups of equipment:

- ☐ standard tools
- ☐ standard measuring and test equipment
- ☐ optical adjustment equipment
- ☐ special tools
- ☐ electrical and mechanical auxiliary aids
- ☐ system oriented measuring and test equipment
- ☐ expendable materials.

Procurement costs of the electronic workshop equipment absorb 78% of the total workshop investment costs and are subdivided as follows:
Maintenance Echelon 2 – 30%
Maintenance Echelon 3 Contact Temas – 22%
Maintenance Echelon incl. REMUS Adapter – 26%

Workshop Equipment for the Weapons/Hydraulics/Power Supply account for the remaining 22% and are allocated as follows:

Maintenance Echelon 2 – 13%
Maintenance Echelon 3 Contact Teams – 6%
Maintenance Echelon 3 – 3%

The prime contractor, Krauss-Maffei, has drawn from experience gained from computerized serial integration and testing of various special test equipments, when developing the workshop equipmenting requirements.

Program Controlled Universal Test Set
This Test set serves for both functional testing and fault diagnosis of complex electronic systems down to the subassembly and module levels. The test set is of modular construction and is suitable for a wide variety of applications. Complete control of the test set is carried out using a microprocessor having both Data and Address busses.

After being switched on the test set automatically carries out a routine check on itself for correct functioning. Written instructions are conveyed to the operator via a text display. Testing procedures are indicated sequentially on this display to the operator.

Due to intensive automation, testing routines on units under test can be remotely controlled by the test set itself. This is an extremely advantageous feature and ensures:

- ☐ Shorter testing times
- ☐ Error free operation
- ☐ Accurate fault diagnosis

The test set consists of a basic unit composed of the following units

- ☐ Microprocessor (RAM 1-k Byte)
- ☐ Display
- ☐ Measurement Devices
- ☐ Signal Source
- ☐ Switching Networks

and also the application oriented

- ☐ Program Module (ma. 128 k-Byte) EPROMS erasable
- ☐ Adaptor
- ☐ Cable Set.

The adaptor provides additional facilities e.g. generation/stimulation and detection of a very wide variety of signals by expanding the measuring channels as required.

Operation is possible without previous operator training and operating instructions.

Fault Diagnosis, Fire Control System
With the fault diagnosis programs stored in this module, the fire control equipment of the Anti-Aircraft Tank can be checked-out, any malfunctioning localised at sub-assembly level.

The test set can also differentiate whether a sub-assembly is DEFECTIVE or MALADJUSTED.

The time required for the running of the complete fire control check-out program is thirty minutes.

With the additional "Self Test" program, all the electrical functions of the test set including cable, plug and adaptor are checked, any part found to be defective is indicated.

Fire Control Equipment Alignment Unit

The Data Module "Fire Control Equipment Alignment Unit" serves for alignment of the sub-assemblies of the Fire Control Equipment in the Anti-Aircraft Tank.

Alignment is necessary after certain sub-assemblies have been replaced and also when tolerances are exceeded due to ageing.

The operator is informed via the test unit display which subassembly and which potentiometer require alignment, and in which direction the potentiometer should be turned.

During alignment the relative values measured are shown on the display.

For documentary purposes, a printer connector is provided on the module, which provides print-out facilities for recording various nominal and actual values.

Fault Diagnosis – Weapons, Hydraulics, Auxiliary Power Unit (APU)

The fault diagnosis programs stored in this module enable the weapons, hydraulics and electrical power supply equipment of the Anti-Aircraft Tank to be inspected. Faults can be localised to sub-assembly and printed circuit board levels.

The test set can also differentiate whether a sub-assembly is DEFECTIVE or MALADJUSTED.

Total time required for the complete check out program for weapons, hydraulics and electrical power supply equipment is thirty minutes.

With the additional "Self Test" program all electrical functions of the test set including cable, plug and adaptor are checked, any part found to be defective is indicated.

Test Bench for Sub-Assembly Repair

The test set can also be used for automatic sub-assembly testing and fault location at both printed circuit board and component levels.

In this case the test set serves as a central measuring and control unit which is then connected to incorporate all of the sub-assembly programs. Assemblies which have been removed from the Anti-Aircraft Tank can be repaired at this Sub-Assembly Repair bench by replacing any faulty sub-assembly. Sub-assemblies which require testing are connected to the central measuring and control unit by means of a special adaptor.

Program selection follows, fully automatically in accordance with the test adaptor which has been inserted. Supply voltages necessary for the individual sub-assemblies are applied as necessary during the running of the program. Simulated loads are also applied and removed in accordance with the program requirements.

For testing operations where manual intervention is necessary (operating switches or buttons or replacing bulbs, fuses etc.) the program is stopped. Instructions necessary for continuing the program are indicated sequentially to the operator via the unit display, in clear text. To safeguard against incorrect manual operation the instructions which have been carried out are re-checked for correctness before the program can proceed further.

System Support

For evaluating the experience of the troops gained during eg: Practice Firing and manœuvers, a team of highly qualified systems engineers are continually available, to analyse the characteristics of the complete system and their behaviour.

The peripheral equipment for the GEPARD AA Tank maintenance involves a cost of between 25 to 30% of the total equipment procurement costs – no small sum. Such an investment is, however, neccessary to ensure optimal availability and effectiveness of the complete system for the next 15 to 20 years while maintaining the high standards required.

Experience from the GEPARD Program, as well as from other branches of the defense industries clearly illustrate that by all such programs it pays to employ performance oriented peripheral experts from the very beginning.

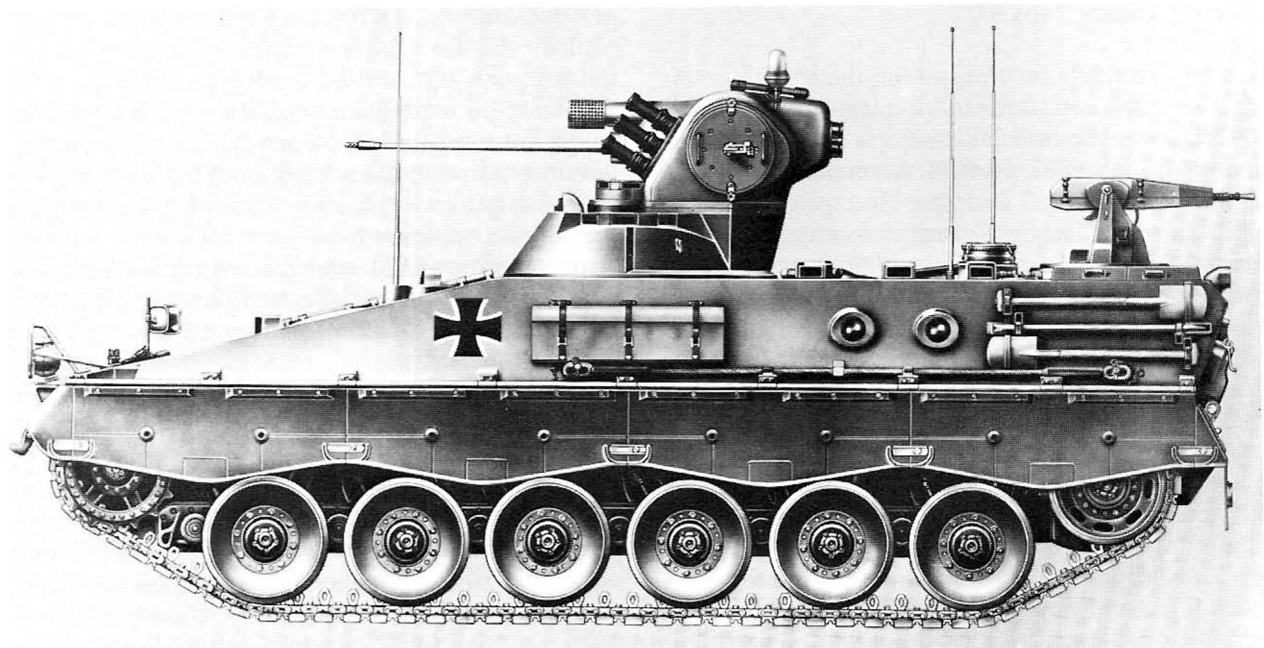
5.6 ROLAND* Anti-Aircraft Missile Tank

In the Nineteen Fifties the development of rockets as precision guided weapons (PGW's) had reached such a stage of technical perfection that it was forecast in many quarters, if somewhat prematurely, that such systems would completely replace the then predominate anti-aircraft gun systems in the air defense role.
The successful countering of the low/very low aerial attack threat posed by modern aircraft is only partially possible by using surface-to-air-missiles such as the HAWK. On the other hand, however, the application of small caliber automatic weapons due to their range limitations provides not always a satisfactory alternative. Therefore, to satisfactorily close this breach which exists between these systems, surface-to-air missile systems such as the Roland system became a necessity. As with the Gepard anti-aircraft tank, the Roland missile tank is also intended to provide mobile and armored units in the field with effective air cover. Whereby, the requirements for mobility, armored protection and instant combat readiness were identical with those established for the Gepard. The armored Roland missile system was conceived in the nineteen sixties and was seen als being complementary support for the anti-aircraft tank due to its increased effectivity in range and altitude.
The Roland missile tank is an autonomous weapon system, similar in concept to the Gepard anti-aircraft tank in so far that all components of the system are integrated within just one armored vehicle.

In the years nineteen fifty-eight and fifty-nine, the German Minister of Defense commissioned an international consortion of companies to investigate low-level, guided missile, air defense systems. In 1962 the Bölkow Co. presented their P 250 missile concept to this panel for consideration. Meanwhile the French Company Nord Aviation were carrying out their own similar project study which was known under the name SABA.

*** For the early history of the surface to air missile see chapter 8**

Armored personnel carrier Marder. Basic chassis for the ground to air missile tank Roland



In a Governmental Agreement dated October 19th, 1964, the Federal Republic of Germany and France agreed to co-operate in developing an Anti-Aircraft Missile System.

As early as 1968 the Procurement Agency (BWB) issued instructions that the originally planned Clear Weather Missile System program, should be extended to include development of an All-Weather version. These systems were then designated as Roland I and Roland II respectively. Whereas Clear-Weather Roland I was intended to satisfy French requirements alone, Roland II, the All-Weather System would be procured by both countries and developed jointly by the Messerschmitt-Bölkow-Blohm and Aerospatiale companies. In 1978, both the Defense and Finance Commitees of the German Parliament voted in favor of the Roland Program.

In 1977 the first test vehicles were delivered to their respective principals in both France and Germany. It was planned that besides supplying one factory test prototype, three military test prototypes, five pre-series systems and one hundred and thirty-five series systems would be delivered to the German Army. Roland II became known in official German Army jargon as Fla-Rak Pz 1 (Air Defense Missile Tank 1).

As carrier vehicle for the system, the chassis of the Marder Armored Infantry Fighting Vehicle was selected. For the first trials vehicle the Rheinstahl-Hanomag RU 242 Rocket Launcher Prototype was choosen in 1967 and modified to suit the Roland System. This armored carrier vehicle was then fitted with the turret which was complete with a special launcher/carrier arm externally mounted on each side which held the missile complete with it's transport/launch tube ready for action. Stowed inside the hull parallel to each side wall are two drum type magazines each containing four replenishment missiles complete in their transport/launcher tubes, providing each system as such with a total of 10 missiles.

Re-loading of the missiles to the launcher arms from the drum magazines is fully automatic. For aerial surveillance and target detection, particulary low level aerial targets a Pulse Doppler Surveillance Radar (developed and manufactured by Siemens AG Munich) featuring high permanent echo elimination facilities is installed. The antenna of this radar is mounted at the highest point of the turret and rotates at the rate of 60 r.p.m., continually monitoring the surrounding air space up to a range of 16 km once per second. With this radar coverage any aircraft from nap of the earth to altitudes of 3,000 meters are recognizable and appear as either luminous spots or dashes on the radar display facing the commander.

By applying the IFF interrogater (friend/foe identification) the commander can determine whether the target indicated is an enemy aircraft or not. Should the target prove to be an enemy, the commander can then pass it over for optical acquisition and tracking to the Gunner seated in the turret. Alternatively the commander can initiate automatic target acquisition and tracking by activating the Tracking Radar/Missile Control Unit which is mounted at the front of the turret. This target tracking/missile guidance unit (developed and manufactured by Thomson CSF, Paris) is a dual channel, monopulse radar with a magnetron transmitter and doppler filter for permanent echo cancelling. The antenna of this unit facilitates target tracking via it's tracking channel and missile control via the missile control channel, whereby radar signals transmitted by the missile beacon located at the trailing edge of one of the missiles wings are used to determine missile course deviation in relation to the tracking radar axis. It is possible for either the missile control radar and/or the missile operator to acquire and track a target until it comes within engagement range. Then via a firing pedal the missile launching sequence is initiated. Hydraulic couplings ensure that the launch arms/missile tubes are constantly directed in the same direction as that of either the Missile Control Radar or Optical Sight.

The missile propulsion units (booster and sustainer motors) accelerate the missile to a speed of approximately 550 meters per second within two seconds of its being launched. This speed is maintained by the sustainer unit right up to missile "burn-out" (approx. 13.2 seconds after launch). At

Ground to air missile tank Roland

launch the missile departs from its launch tube powered by the booster motor the sustainer motor cuts-in shortly after the missile leaves its tube. Upon leaving the tube the missiles folded wings open to their flight position, stabilising fins near the nose of the missile also emerge from their stowage positions. From this moment full missile flight control becomes established. Fitted at the tail of the missile, facing off are two infrared tracer flares which ignite and burn for the duration of the missiles flight and serve as tracking aids in the clear weather mode.

The infrared radiation from these flares is measured and evaluated as missile course data via an infrared localiser integrated within the sighting unit. Target position data from the sighting unit together with missile course data from the infrared localiser are collated and processed by the Command Computer. The computer calculates any missile course corrections necessary, these are then transmitted by radio to the missile to bring it to the correct target interception course. For this purpose a Command Transmitter Unit working in the cm wavebands is used. The missile receives these signals via a command antenna fitted to the trailing edge of one of its wings, they are then processed via an appropriate control unit into pulses, these pulses are then used to steer the two exhaust jet deflectors sited symmetrically at the exhaust output nozzle to bring the missile to the desired flight path. Both the missiles altitude and azimuth courses are controlled in this manner. Should the missile achieve a direct hit on its target an impact fuse initiates detonation of the shaped, hollow charge warhead. If however a near miss occurs and the missile passes within ten meters of the tar-

get an electro magnetic proximity fuse initates detonation of the missile warhead.

Whereas, with guns "hit probability" of a single shell is relative to the number of shells fired, with a missile "hit probability" is directly influenced by the capability of the individual missile against its target. Roland requires approximately 13.2 seconds to travel six kilometers. Under the most favorable conditions four missiles can be launched in one minute.

The missile system is effective against aerial targets travelling at speeds of up to Mach 2 (approx. 666 m/s)

- ☐ at ranges from 500 to 6,000 meters
- ☐ and altitudes of 50 to 5,000 meters.

Targets can be located by the Surveillance Radar even while the system is on the move. Missiles can be launched within seconds after the vehicle coming to a standstill.
The missile itself is 2.4 meters long, 0.16 m diameter, weighs 62.5 kilos and is simple, compact, light to handle and maintenance free. When compared with other weapon systems, procurement costs are relatively low making its procurement in effective quantities an very viable proposition.

Combat weight of the Roland II Anti-Aircraft Missile Tank is 32.5 tonnes. Stowed within the hull of the vehicle are:

- ☐ Surveillance Radar Transmitter/Receiver
- ☐ Radar Display and IFF Recognition facilities
- ☐ Operators Console and Indicators
- ☐ Two drum type missile magazines each containing four missiles
- ☐ Power Supply Unit (MWM 25 kVA)
- ☐ Hydraulic Pumping Aggregates
- ☐ Radio and Intercom System
- ☐ Operation Control Units for both Commander and Driver

The turret alone weights 6.5 tonnes complete. Besides housing the Missile Operator, the following equipments are stowed within it:

- ☐ Command Radar Link Antenna complete with Transmitter/Receiver
- ☐ Radio Command Transmitter and Antenna
- ☐ Sighting Unit (optical)
- ☐ Goniometer
- ☐ Command Computer
- ☐ Two Missile Launcher arms complete with Missiles
- ☐ Turret Hydraulic Pump aggregates
- ☐ Operational and Control Equipment

Ongoing trials in Germany, France and the United States have confirmed the Roland Anti-Aircraft Missile Tank to be capable of:

- ☐ Fast Reaction time
- ☐ Rapid Firing, due to the fully automatic reloading facilities
- ☐ Favorable delay free mode-of-operation selectability between "Clear Weather" and "All Weather" options during target engagement
- ☐ High Hit Probability
- ☐ Optimal mobility and air transportability
- ☐ Continual combat-readiness provided by the surveillance Radar while on the move.

Complete international program management responsibilities are assumed by the Euromissile Company in Fontenay-aux-Roses, France. The French company Aerospatiale of Paris are responsible for French missile production, Messerschmitt-Bölkow-Blohm in Munich for German missile production. Final integration and delivery of the Roland II Missile Tanks for the German Army is done at the MBB, Kassel Facility by the Thyssen-Henschel Co.
Series production of the Roland II weapon system began in 1978 with the delivery of the pre-production systems and should be completed in 1983.

While in France both the Roland I and II systems are mounted upon the chassis of the AMX 30 MBT (series production began in December 1977), the United States Army intends to use the chassis of the self-propelled, armored howitzer M 109 (M 975) (Authorized Licencees are Boeing and Hughes Aircraft Companies).
In the German Army, the Missile Tanks 1 will be deployed starting in 1979 at Corps level, replacing the 40 mm L/70 gun systems. Each of the three German Corps are to receive thirty-six Missile Tanks. These will be combined to form three Corps Air Defense Regiments.

6. Air Defense and Anti-Aircraft Missile Tank System Studies carried out by Krauss-Maffei

6.1 Air Defense Missile Systems based upon the Leopard Main Battle Tank (Studies)

In 1978, under contract by the Dutch Company, Hollandse Signaalapparaten BV., Krauss Maffei completed a feasibility study. The objective of the study was to investigate mounting a surface-to-air Missile Tank Turret on a modified Leopard MBT chassis. Three different types of missiles were considered.

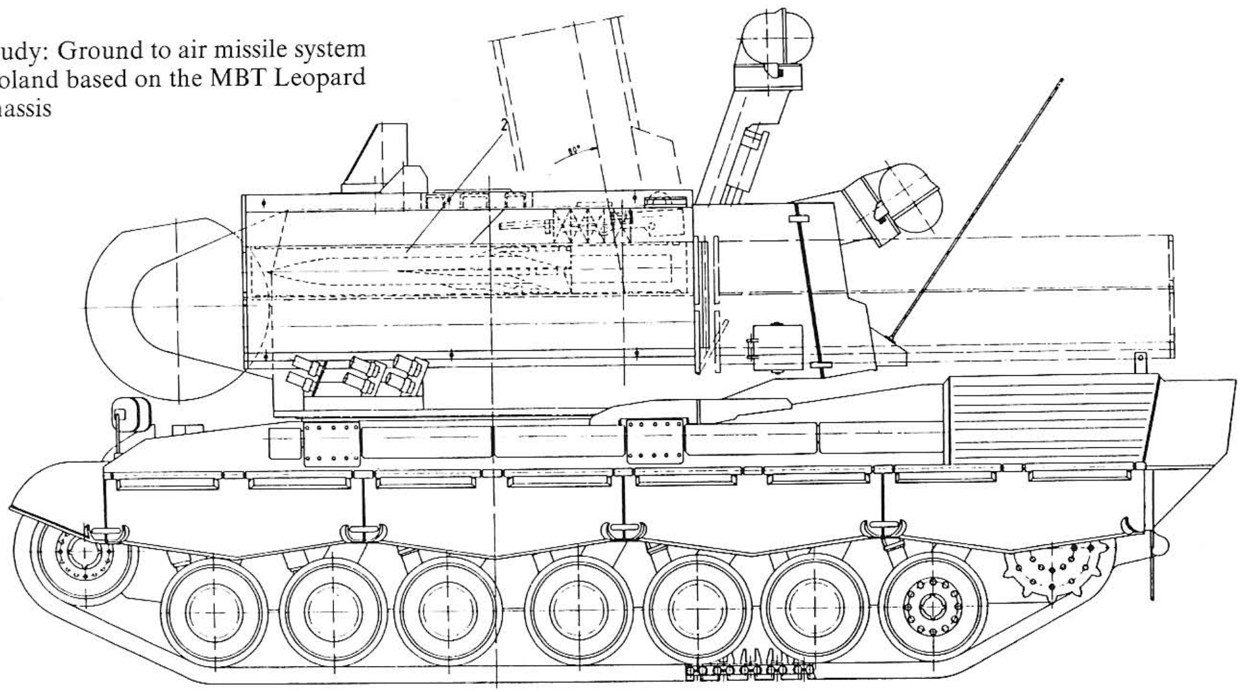
6.1.1 "Roland" Surface-to-Air Missile Turret

By considerable retention of most of the standard CA 1 turret, a fully autonomous, air defense missile system was created. In all it was planned that the complete system would carry ten, ready-to-fire "Roland" Anti-Aircraft Missiles. Besides which, for self-defense purposes two 7.62 mm FN Machine Guns and two "Swingfire" Anti-Tank Missiles were proposed. The three man crew concept of the CA 1 was retained. In the roof of the turret the standard Gunner's periscope was replaced by an optronic missile Tracking Unit.

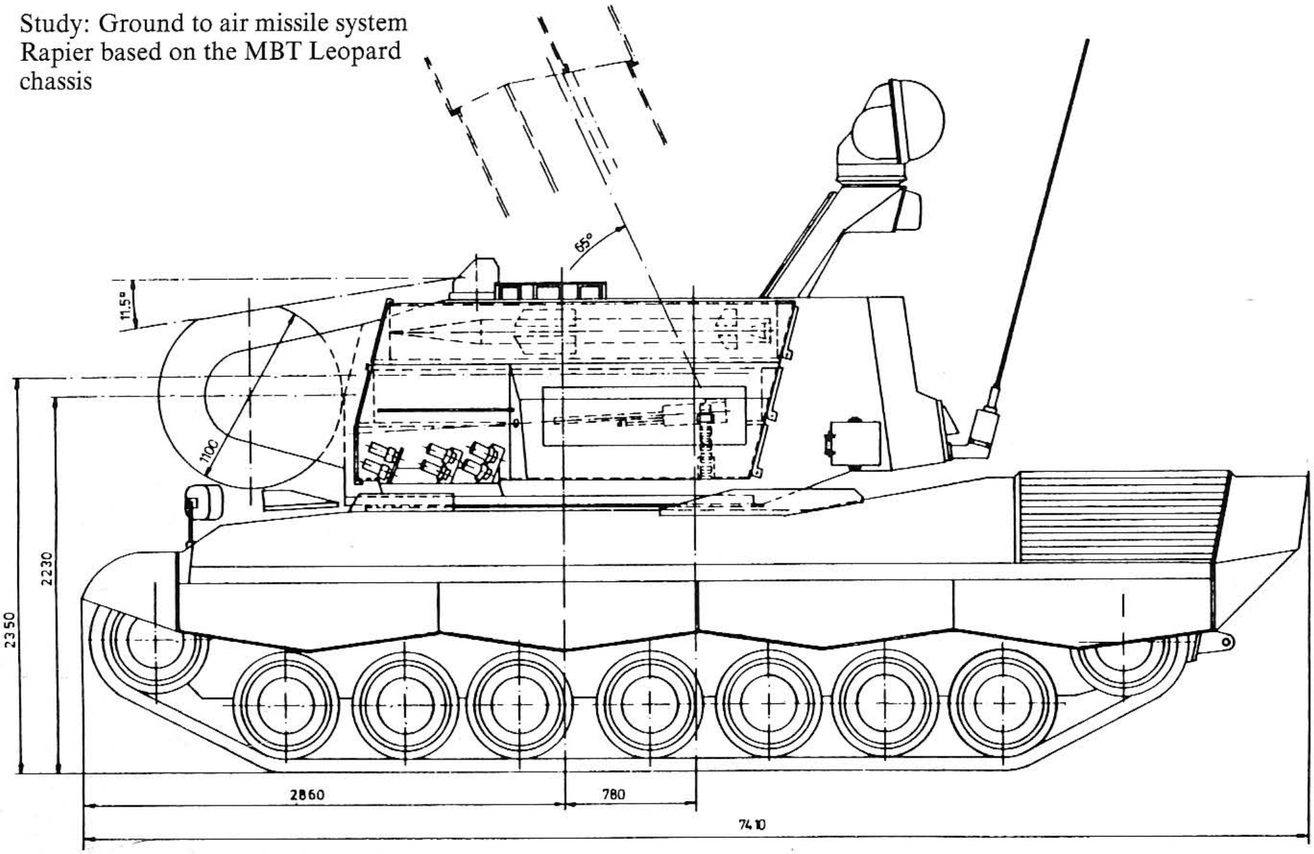
6.1.2 "Rapier" Surface-to-Air Missile Turret

Also with this concept the CA 1 turret remained practically unchanged, two laterally mounted missile launchers replacing the 35 mm cannon. Each launcher containing five of these British develop-

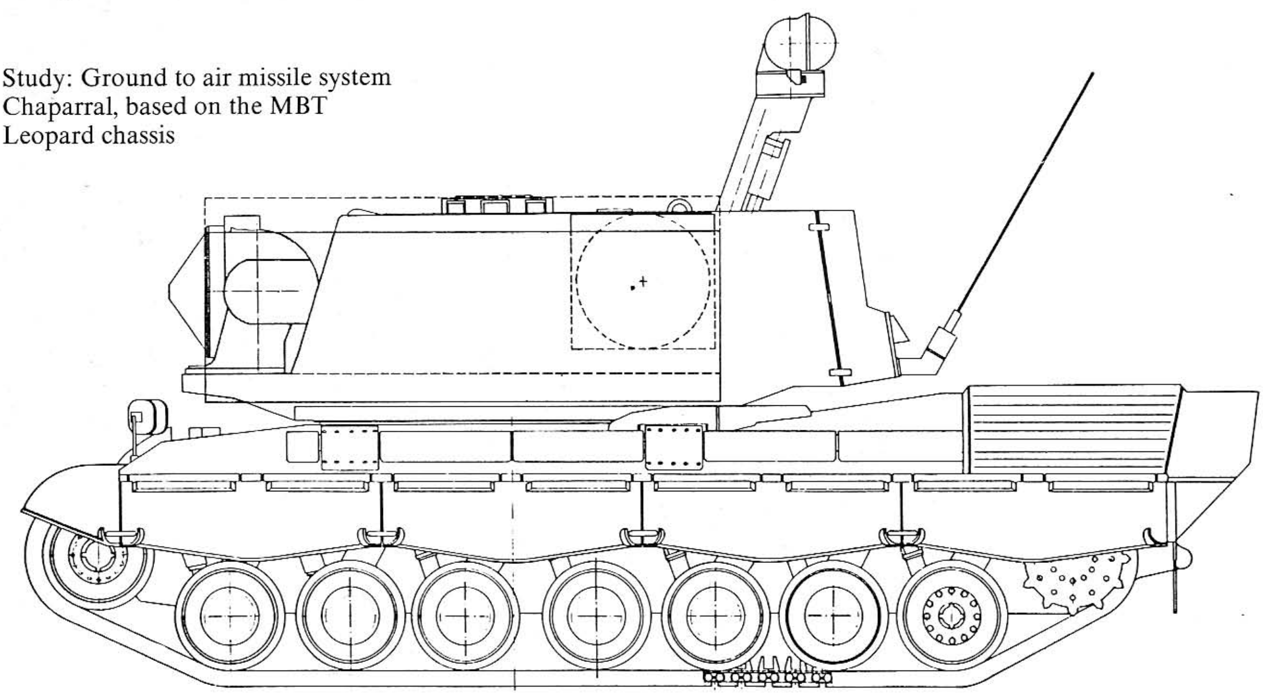
Study: Ground to air missile system Roland based on the MBT Leopard chassis



Study: Ground to air missile system Rapier based on the MBT Leopard chassis



Study: Ground to air missile system Chaparral, based on the MBT Leopard chassis



Rundsuchradar-Anlage

Folgeradar-Anlage

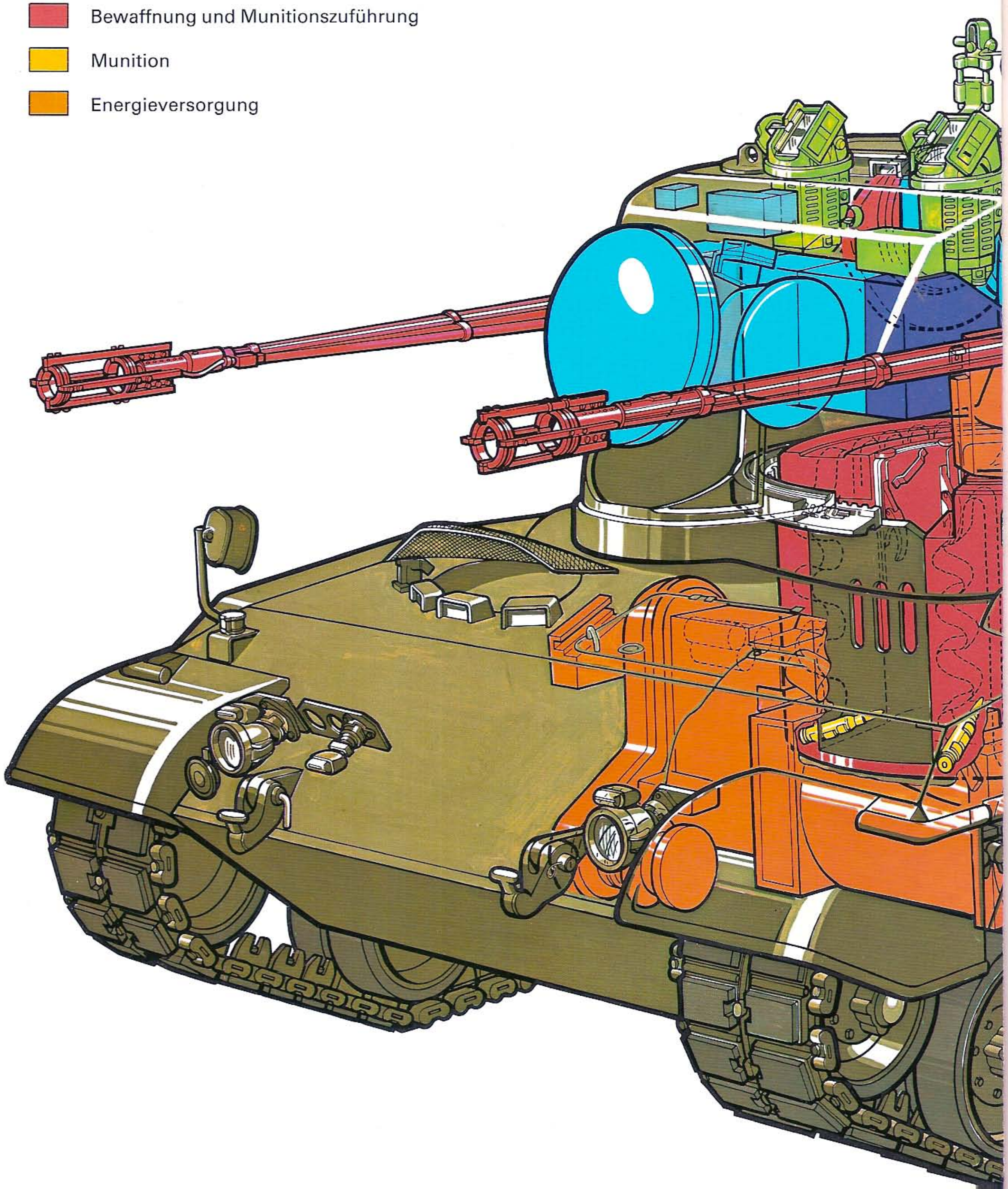
Feuerleitrechner und Pultteil

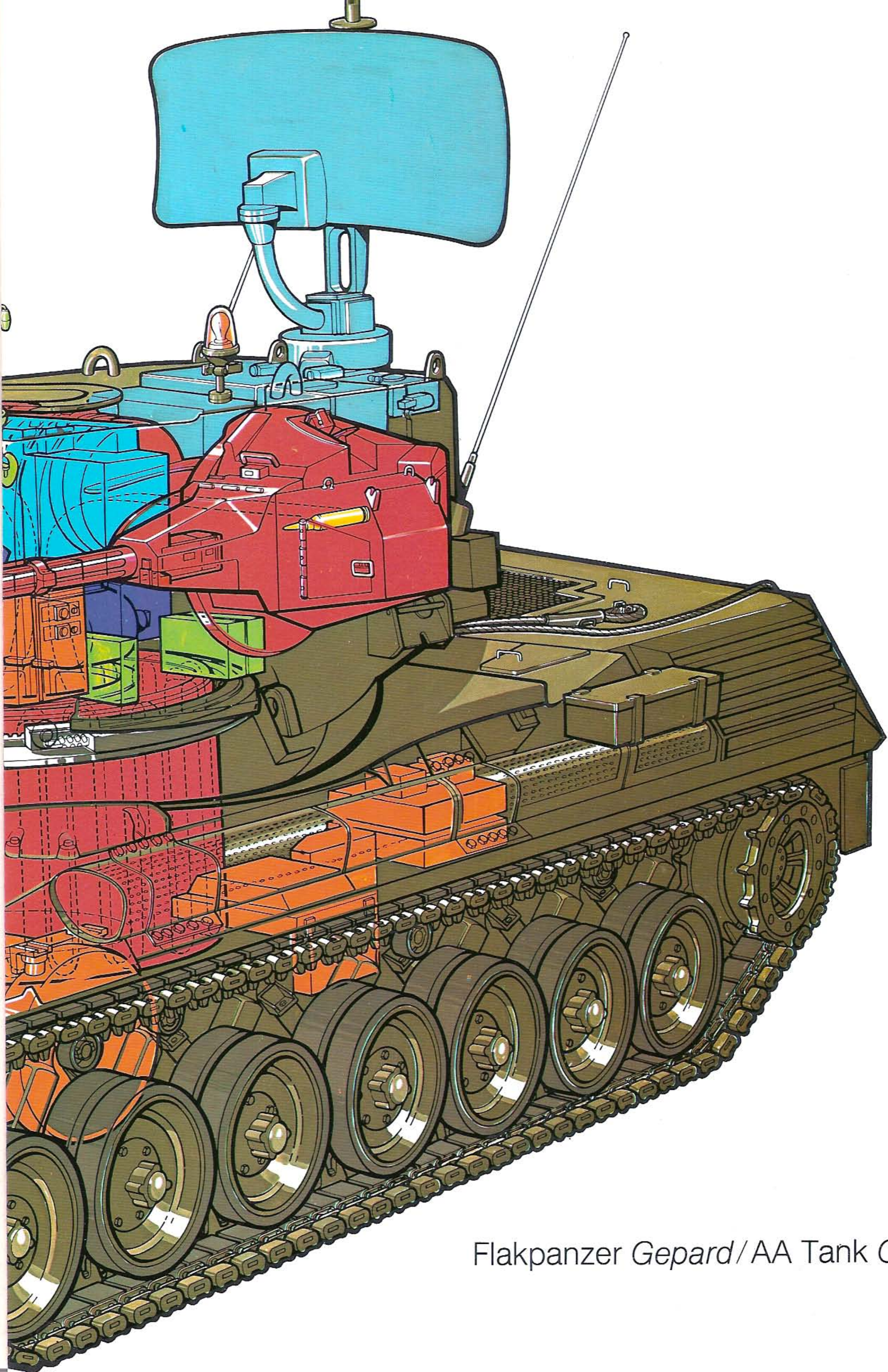
Optik

Bewaffnung und Munitionszuführung

Munition

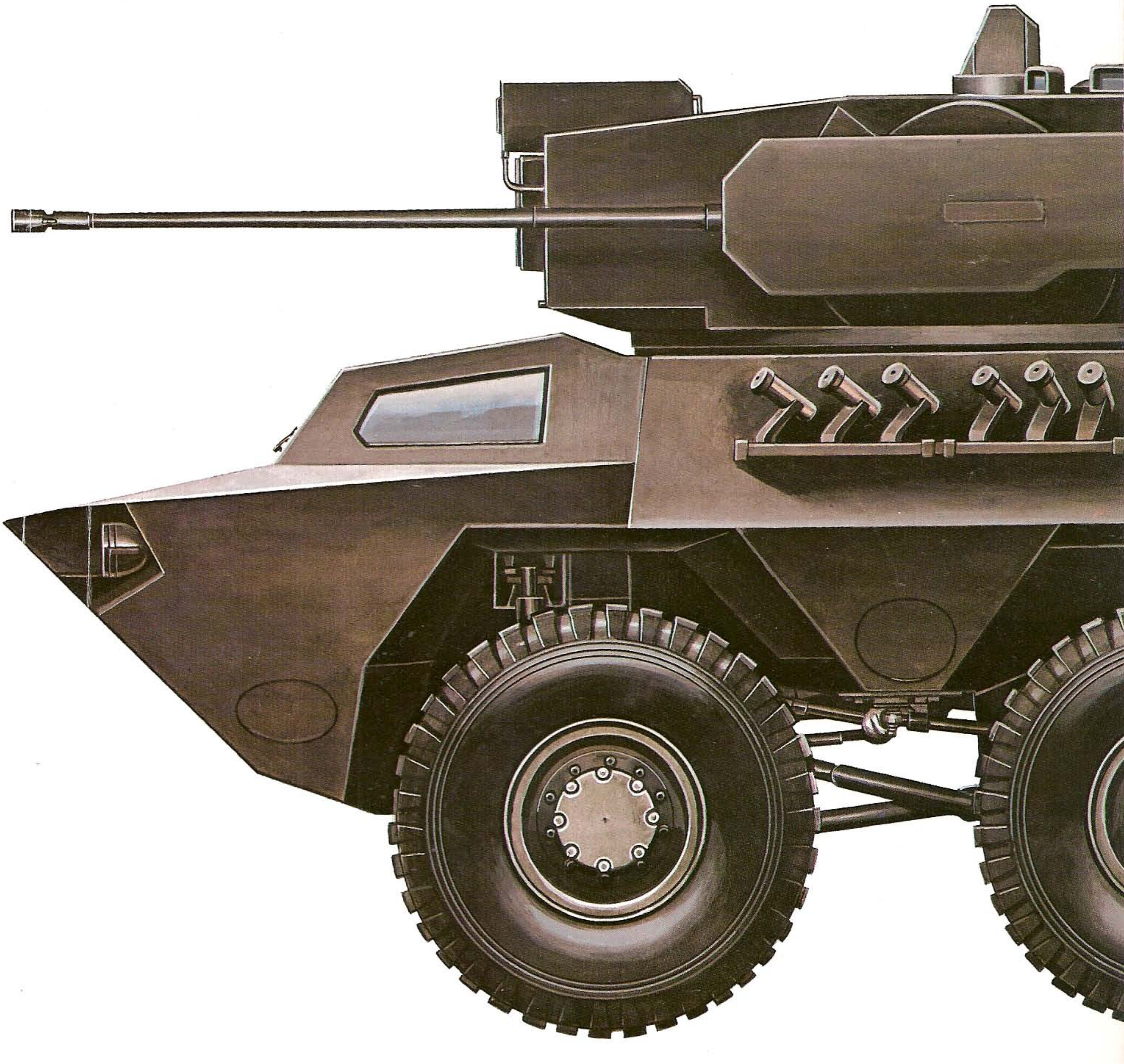
Energieversorgung





Flakpanzer *Gepard* / AA Tank *Gepard*

Flakpanzer AAAT / Anti Aircraft Armored Truck AAAT



ed surface-to-air missiles ready to fire. The means of self-defense which were provided being identical which were proposed for the "Roland" concept. Again the standard Gunner's periscope was replaced by an Optronic Tracking Unit.

6.1.3 "Chaparral" Surface-to-Air Missile Turret

The "Chaparral" lightweight, supersonic, surface-to-air missile requires no guidance after launching, an infrared target seeker head serves this purpose. "Chaparral" is a derivative of the "Sidewinder" AIM-9D air-to-air missile. Eight "Chaparral" missiles (4 each side) could be stowed in armored launchers on the almost standard CA 1 turret. (Guns removed as in both other concepts). Once again, for self-defense purposes two "Swingfire" Anti-Tank Missiles were included in the concept. As target tracking was unnecessary due to the missile infrared seeker, the Gunner periscope remained standard, only an additional "black-box" adaptor was necessary for providing guidance for the "Swingfire" missiles.

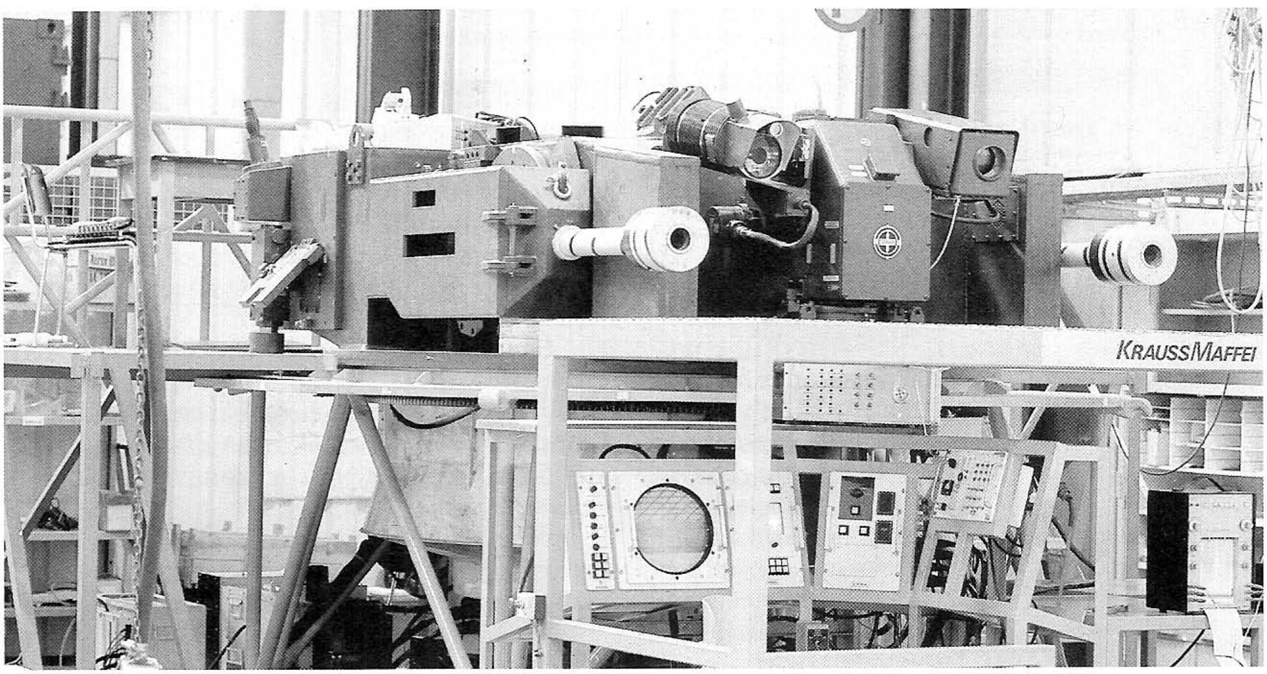
6.2 Twin 30 mm, Wheeled (6 × 6), Armored Anti-Aircraft Vehicle "Wildcat"

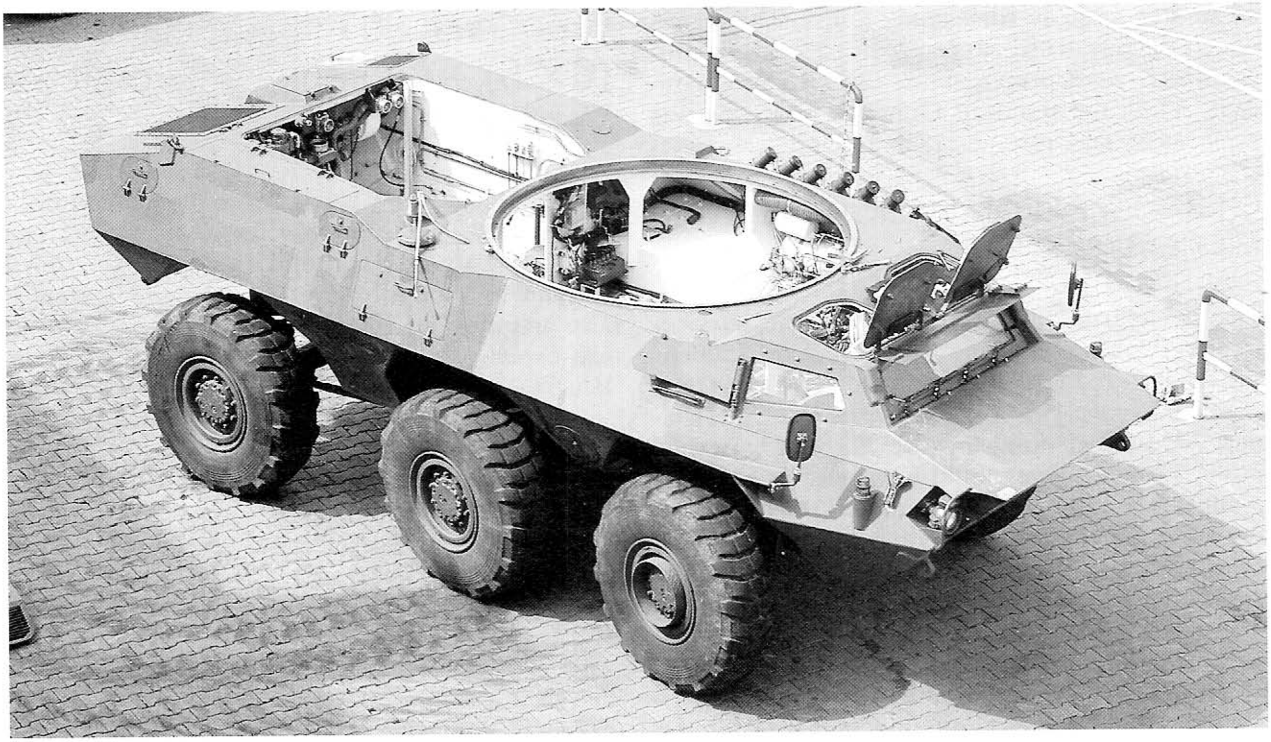
The "Wildcat" Air Defense System employs in its fundamental conception a far less complex and lighter chassis than that of the "Gepard" or "CA 1 AA-tanks. Similarily, the Fire Control System is also simpler and therefore not only considerably less expensive, but also easier to serve and maintain.

"Wildcat" as a system is the result of close cooperation between the companies, Krauss-Maffei, Siemens, Hollandse Signaalapparaten and Mauser. The carrier vehicle used is based upon the chassis of the well known, Daimler-Benz designed, Multi-Purpose-Armored Vehicle (6 × 6), TPZ-1 or "Fuchs".

This extremely cost-effective, armored, all wheel driven Air Defense Vehicle has been conceived particularly for NATO member states, who for fi-

Integration testing Device Wildcat.





Chassis of Anti-Aircraft system Wildcat.

nancial or other reasons were unable or decided not to procure either the "Gepard" or "CA 1" Anti-Aircraft Tanks.

Firepower

"Wildcat" is armed with two, high performance, 30 mm, Type 173 Model F, Machine Cannon of the latest design which are manufactured by the Mauser Company of Oberndorf. These weapons are equally effective for engaging either aerial or ground targets. Besides, their rather high rate-of-fire of 800 rounds per minute and muzzle velocity of 1,040 meters per second, the shell of the pre-belted ammunition takes only 4.5 seconds to travel 3,000 meters. Each weapon consists of only seventy-two mechanical parts, weighs 141.5 kg, and can be dismantled and re-assembled very quickly without any tools being necessary. These machine cannon remain fully operational under extreme environmental conditions without any loss in performance. "Wildcat" carries a total of five hundred rounds of anti-aircraft ammunition (250 rounds per gun) in two turret well magazines. A further twenty rounds of AP ammunition for each weapon can be quickly selected for self-defense against ground targets.

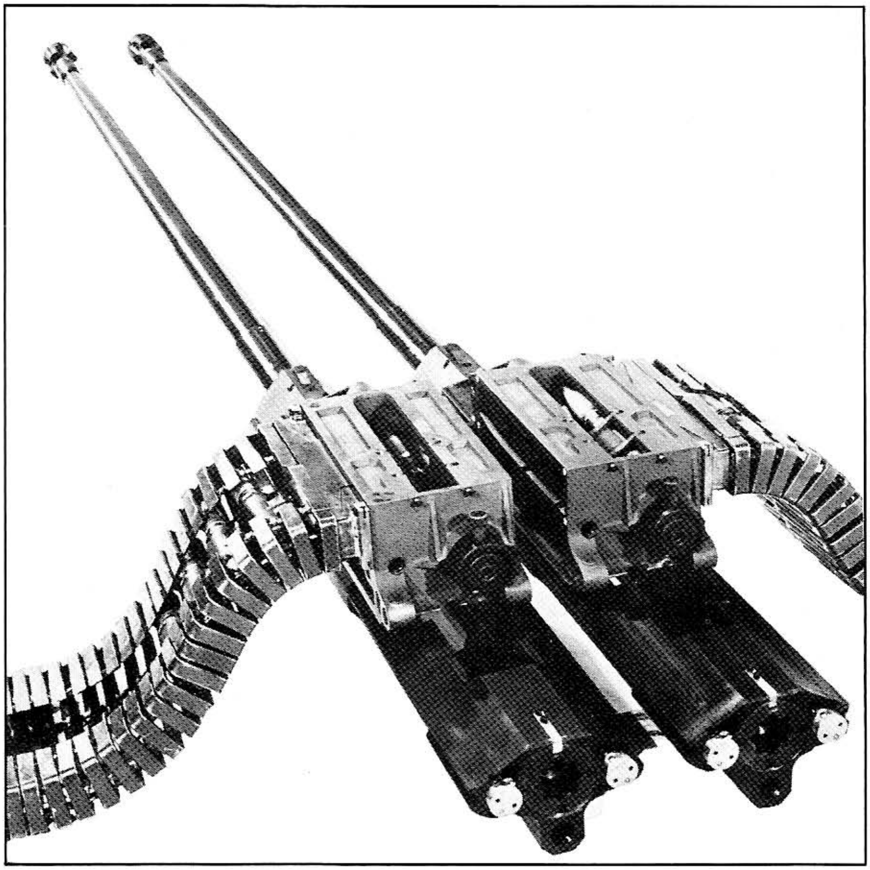
Ammunition used is the 30 mm GAU-/8A ammunition and is available as either HE I, AP I or TP type rounds all of which can be obtained with or without a tracer. Each shell weighs approx. 370 g. The duration of individual bursts of fire can be pre-programmed for aerial engagements, ground targets can fired upon with individual rounds.

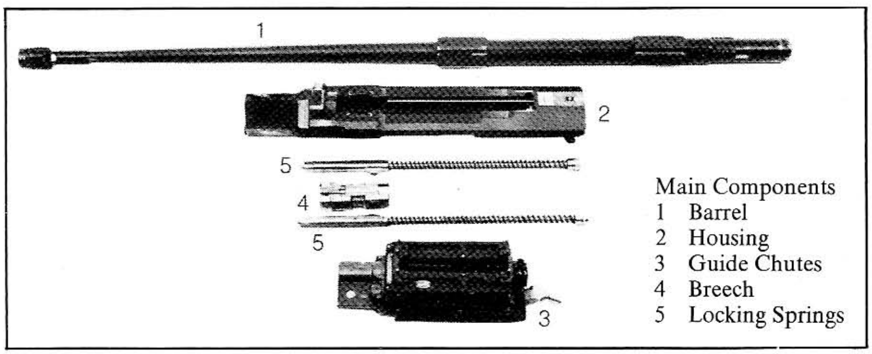
Fire Control System

The quality of the fire control system is a decisive factor in determining the combat ability of the Air Defense System. Therefore the complete "Wildcat" fire control system is made up of major subunits such as the:

- ☐ Independantly operating Surveillance Radar complete with Friend/Foe Interrogator (IFF)
- ☐ radar tracking unit or alternatively TV- or Infrared Tracker complete with Laser Range finder as selectable options

Mauser 30 mm Machine Cannon, Type 173. Model F, with Main Components.

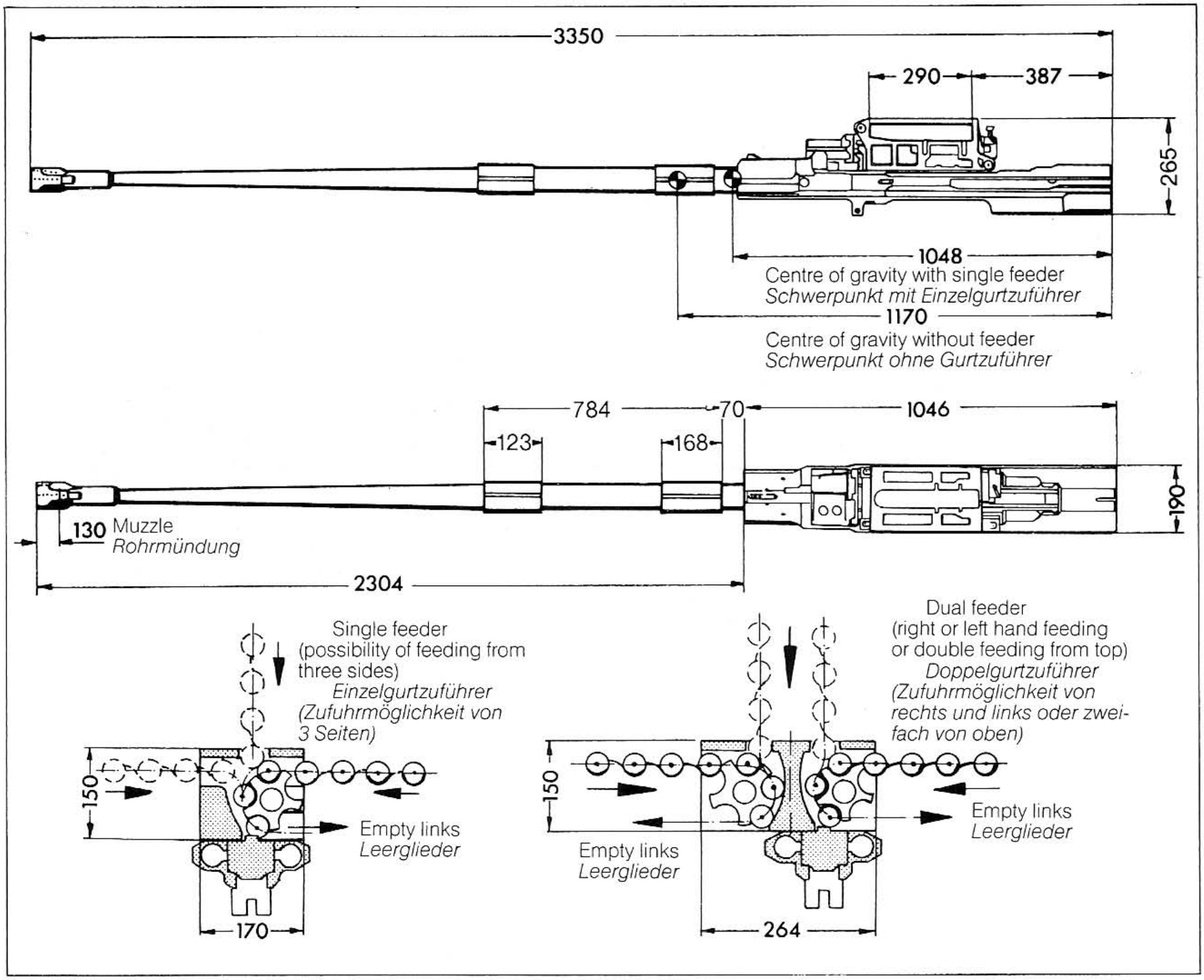




- ☐ digital fire control computer complete with integrated system logic
- ☐ periscope

By using the surveillance radar, surrounding air space up to a range of 10 km can be supervised, even while on the move or operating in ECM environment. System performance is only very slightly inhibited by bad weather. The process of target identification and tracking is basically identical to that of the "Gepard". The fire control computer enables optimal computation of the gunnery lead angles.

Armor protection
Wheeled AFV's can basically only be armored to



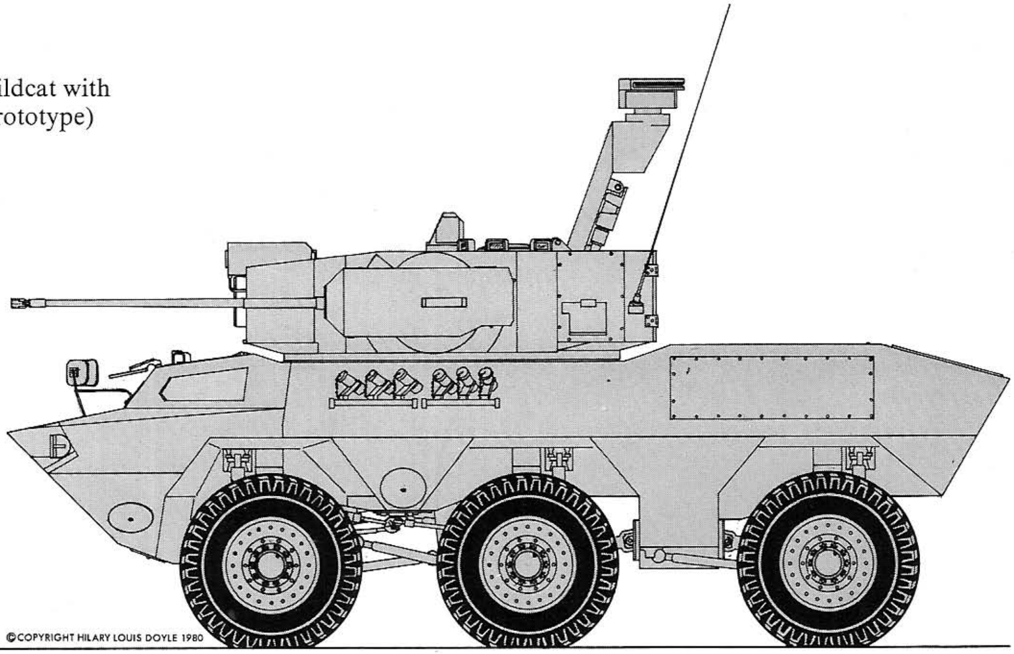
Main measurements of weapon with feeder system:

Machine cannon MK 30 mm × 173 Mauser, model F with exchangeable different link feeders

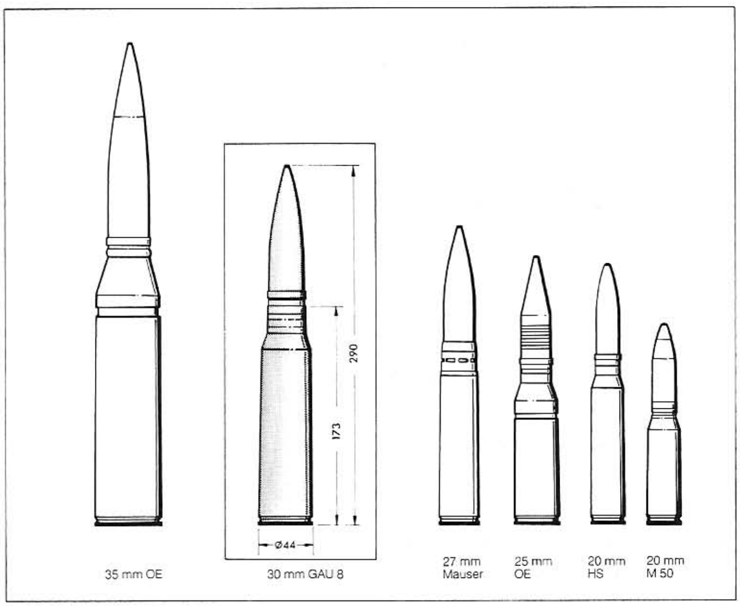
caliber	30 mm	belt force	1500 dN
Cadence 800 rounds per minute		weight of weapon complete	132,5 kg
muzzle velocity V_0 1040 m/s		weight of barrel	53 kg
flight time to 3000 m 4,5s		weight of weapon housing	60,5 kg
gas pressure	3800 bar	weight of belt feeder	19 kg
recoil force	1800 dN	ammunition 30 mm × 173 (GAU-8/A)	

provide effective protection against small-arms fire and grenade fragments. However, by applying the latest materials for manufacturing armor plate and using constructional shapes which have been derived for enhancing this protection ballistically it is possible to optimise protecting the AFV crew. Furthermore in the case of the "Wildcat", crew protection is increased by the extraordinary mobility and low silhouette. Supplementary equipment for the vehicle such as the NBC-protective system, smoke grenade launcher units etc. are readily available. The vehicle hull is of monocoque construction, the main engine compartment and both bullet-proof fuel tanks are isolated from

Anti-aircraft system Wildcat with 30 mm twin cannon (prototype)



Comparsion of 30 mm ammunition with other existing machine cannon ammunition



30 mm × 173 GAU-81/A

Muzzle velocity V_0	1040 m/s
weight of round mp	369 g
round energy E_0	204 KJ
weight of round m_0	684 g
length of round L	290 mm
volume of round v	0,44/dm³

the fighting compartment by means of gas and fireproof steel bulkheads.

Mobility

The basic "Wildcat" vehicle concept is founded upon that of the "Fuchs" Multi-Purpose Armored Vehicle (Transportpanzer 1) (6 × 6) which is currently being procured in quantity by the German Army. Years of research and intensive trials undertaken during the "FUCHS" development have resulted in an extremely capable, wheeled cross-country vehicle, which has proven itself to be a worthy contempory to any of its modern, tracked counterparts. However, "Wildcat" compared to

tracked vehicles, is capable of much higher road speeds, is economical to operate and possesses a cross-country ability "par excellence" for a wheeled vehicle. Rapid acceleration, extensive operational range, agility in negotiating obstacles combined with its optionally available amphibious capability all serve to make this vehicle outstanding in its class.

"Wildcat" is powered by a standard, commercial Daimler-Benz, OM 402 A, Exhaust Turbo-charged V8 Engine, having a power output of 235 kW at 2,500 r.p.m. All six wheels are driven via a ZF, 6 gear transmission which also includes a torque converter. This extremely compact power-pack can be removed for overhaul or replaced within a matter of minutes. It can also be test-run when removed.

All three of the axles fitted are taken from the Daimler-Benz standard commercial range of products, their ready, economically-viable procurement is thereby assured.

The axles are supported by progressively acting coil-springs which allow a maximum axle travel of 290 mm. Sectional alloy rims fitted with 14.00-20 tires assure adequate ground clearance. Steering of both the front and centre axles is hydraulically assisted. Dual circuit, hydraulic, compressed air assisted brakes are standard, all-round.

Tactical Application

"Wildcat" as a weapon system is ideally suited for a wide variety of tactical applications, it is in fact an extremely economical multi-purpose weapon system. It is furthermore possible to replace the machine cannon by surface-to-air missile racks if requested. The turret's compact dimensions facilitate its being mounted on a variety of alternative wheeled or tracked carrier vehicles.

Currently the following system variants are being developed:

Table 9

Variant	V1	V2	V3	V4	V5
IFF	Visual	via Data Link	Integrated	Integrated	Integrated
Weather	Clear Visibility	Clear Visibility	Clear Visibility	Hazy	All-Weather
Time	Day	Day	Day	Day/Night	Day/Night
Target Acquisition	Optical	Optical Data Link or PPI	Optical Radar	Optical Radar	Optical Radar
Target Tracking	Automatic	Automatic	Automatic	Automatic	Automatic
Equipment					
Periscope	X	X	X	X	X
Surveillance Radar	–	Data Link or PPI	X	X	X
TV-Tracker	X	X	X	–	–
Laser Range Finder	X	X	X	X	–
IR-Tracker	–	–	–	X	–
Radar Tracker	–	–	–	–	X

By extensively integrating many standard commercial sub-assemblies and components an economically viable weapon system has been realised, capable of fulfilling to a large extent the same tasks as both the "Gepard" and "CA 1" Anti-Aircraft Tanks. "Wildcat" users can rest assured that they have a multi-purpose weapon system at their disposal. A system possessing the necessary equipment, mobility and operational range for providing an autonomous 24 hour, total combat capability.

Air Defense system Wildcat – version V3 ▲ ▶

Air Defense system Wildcat – version V5 ▼

7. Anti-Aircraft Fire Control Equipment Developments*

7.1 Light and Medium Anti-Aircraft Gun Sights and Computing Units

Each light and medium anti-aircraft batterie consisted of three troops, each troop equipped with three pieces of ordnance. The troop commander was responsible for directing the combined fire power of his weapons.

Unlike the heavy anti-aircraft batteries, no centralised fire control (Command Centre) was available to troop commanders.

The technical responsibility for directing firing rested solely with the troop commander. Each piece of ordnance was fitted with its own sighting and laying equipment, in some cases a range finder (1 m Base Range Finder) was available.

Aiming corrections while firing were possible even at this time, adjustments being made by using the sight or executed directly by the gunner. The trajectory of "tracer" rounds being fired providing the necessary visual observance guides. However in spite of sighting and gun laying equipment being almost continually improved, the major element of fire control remained a human factor – the gunner. It was the gunner's skill and judgement which was decisive as to whether or not the gunnery operation was a success or failure.

Every piece of light air defense ordnance, including anti-aircraft tanks were equipped with their own sighting and gun laying devices specially made for engaging aerial targets. As the years passed by complete series of anti-aircraft sights were developed, from very simple linear sights to complex and effective electrical anti-aircraft sights.

☐ Linear Sight 21 (2 cm – Anti-Aircraft Cannon 30)
The oldest light anti-aircraft gunnery sight was the Linear Sight 21, in the early years of World War II this sight was often found with the 2 cm cannon as a purely auxiliary sight. Range, course and speed of the aerial target, its climbing or diving angles and sighting elevations, all could be quickly set manually on the sight. This served to provide the necessary lead angles for the guns prior to opening fire.

☐ Anti-Aircraft Sight 35 (2 cm A-A Gun System, Types 30 and 38).
The Type 35 Anti-Aircraft sight was a reflector type sight with a mechanical target course and speed calculator. This sight provided simplified, improved operation together with a continuous flow of firing data. A target's course and azimuth lead angles were projected to the same level sight, effectiveness depended on the accurate setting of the range, course and air speed of the target. Changes in altitude by the target could also be accounted for. Generally most of the 2 cm Type 30 A-A Gun systems were equipped with this sight. In some cases however as an interim measure individual Type 38, 2 cm A-A systems were also fitted with this same sight, until they were retro-fitted with better electrical sights.

☐ Anti-Aircraft Gun Sight, Type 38 (electrical) (2 cm 39 A-A Guns)
The Type 38, A-A sight was an electrical gunnery sighting device, which after initially acquiring a target, could provide continuous azimuth, elevation and sighting angle data of that same target.

*** Author Michael v. d. Sanden, Siemens Co.**

Both the target's azimuth and angular elevation speeds were determinable by using an electrical tachometer, coupled with the traversing and elevating drives of the guns. Target slant range was also measured electrically (battery powered) via a sliding rheostat incorporated within the sight. Both tachometer and battery current were transposed into trains of informative current, were evaluated as firing data and then fed into the illuminated sighting reticle in the sight head. This was done in such a way that the target remained acquired optically for the gunner, the weapons however were automatically directed to the lead angle/target interception position. One of the major advantages of this development was the amount of time which was saved determining more precise firing data electro-mechanically, when compared with the more generally used manual method. This sight was eventually adopted as standard for the 2 cm Type 38 A-A Gun Systems.

☐ Anti-Aircraft Sight 40
Both working principle and construction of this sight were very similar to that of the Type 38 sight, only minor modifications to suit its adaption for use with the 2 cm Quadruple A-A Gun System being necessary.

☐ Anti-Aircraft sight 33 (3.7 cm Type 18 and 36 A-A Guns)
This sight was used in conjunction with both the 18 and 36 Types of anti-aircraft guns, it worked very similar to that of the Type 35 sight which was used with the 2 cm Type 30 Anti-Aircraft Guns.

☐ Anti-Aircraft Sight 37
The 37 sight was a mechanically computing unit designed especially for use with the Type 37, 3.7 cm Anti-Aircraft Gun System. Changes in azimuth and elevation of an acquired target were determined mechanically using trigometrical values. Range was either estimated or called out by the operator of a 1 m base Range Finder, the range was then used to set the sights manually. Firing value calculations were carried out using a three stage clockwork motor. Angular sighting corrections were also possible as were corrections necessitated due to environmental or other miscellaneous influences.

☐ Anti-Aircraft Sight 43 (self-propelled A-A Guns "Furniture Van").
This sight was fundamentally identical with the 37 sight. It was used with the improved Type 43, 3.7 cm Anti-Aircraft Gun systems.

☐ Circular Reticle Sight (Anti-Aircraft Tank "Kugelblitz") (Ball Lightning)
The above sight was a relatively simple device working along very similar principals to those of the Linear Sight. It was necessary to introduce this sight into service in 1944 due to difficulties in obtaining the necessary raw materials for manufacturing the older more complex sights used earlier with the Type 37 and 43 3.7 cm Anti-Aircraft Guns. A targets speed, course, climbing and diving angles had to be set manually.

☐ Circular Reticle Sight 30/38 (Self-propelled, Quadruple 2 cm A-A Gun Carriage, Anti-Aircraft Tank Mk IV "Whirlwind")
Once again in comparison to electrical sights, this was an extremely simple aiming device for the quadruple 2 cm Anti-Aircraft guns. It was in fact a derative from an older sight which had originally been developed for A-A machine guns. In the latter part of the war this sight was used extensively.

☐ Anti-Aircraft Sight 41
This sight was specifically produced for use with the temporarily produced Flak 41, 5 cm-caliber anti-aircraft gun. Its construction technically and its method of operation was very similar to that of the 38 and 40 types of sight.

☐ Optical Focusable Sight (3.7 cm Flak 43) Anti-Aircraft Gun
Early in 1945, the Zeiss Co. brought out a simplified, robust sight for the 3.7 cm caliber Flak 37/43 A-A guns. This sight allowed targets courses to be taken into account, it worked in fact in much the same manner as many proven sighting devices already fitted to earlier light and medium Anti-Aircraft ordnance. However

it was a war-type product, simplified at the cost of some of its accuracy.

☐ Fire Control Unit (Unit 58) for 5.5 cm Anti-Aircraft Batteries
Although as already mentioned this 5.5 cm weapon never entered field service, it did provide a brief glimpse as to what could be expected to be developed in future years and is interesting within its own right. As primary air defense units, each medium Flak battery of four or six guns would receive a target calculating machine (System Castor). This calculator was then coupled via electro-mechanical transmission unit with each individual field piece in the battery (a construction never fully completed). These transmissions were then connected with a gunner corrective device, the positional difference calculator 44, (a service ready development) fitted to each gun. The co-ordinative performance of the target calculator and aiming corrector considerably increased the hit possibilities (direct hits) of the battery. Now for the first time a batteries fire power could be concentrated directly at a target. In contrast to the normal practices of the heavy Flak batteries of laying barrage fire in the general proximity of a target by using diversely layed guns.

7.2 Radio Ranging Equipment (FuMG) as Air Warning and Fire Control Equipment

☐ This form of radio surveillance worked upon the identical principles as those of the echo depth sounder. Electrical pulses being transmitted at regularly spaced intervals, these pulses upon striking a solid body, for example an aircraft, are reflected. These reflected pulses, echoes, are picked up by a receiver integrated within the system, usually sited in the close proximity to the transmitter. The time taken between a pulse being transmitted and its reflected echo received, is shown as target range on a display. Simultaneously to this, other elements of the system determine the targets position and thereby its course.

☐ The following descriptions limit themselves to only the most important features of German Radio Ranging Equipments, therefore their various, individual technical details have not been reflected. The details relevant to and directly affecting Anti-Aircraft Artillery being the only exceptions. It must be remarked however, that the heavy Flak batteries on the Front were very rarely, often only temporarily equipped with such radio ranging equipments. The extremely fragile tubes (80 to 100), in use at that time did not facilitate the battlefield deployment of such equipment, desirable as it may have been.

The Radio Ranging Units "Freya", "Mammut", "Wassermann"

☐ "Freya" was the first radio ranging unit to be commissioned into field service by the German Wehrmacht. It worked in the 2.4 meter waveband and could be used to ascertain effective aerial surveillance for ranges in excess of one hundred kilometers. This range in terms of the aircraft speeds of that time (1938) gave approximately twenty minutes warning. More than adequate time for "scrambling" squadrons of interceptor fighters, or alerting the anti-aircraft gun batteries. During the course of the war, other systems which stemmed basically from the "Freya" were developed, with more extensive ranges. Some systems such as "Mammut" and "Wassermann" being capable of detecting approaching aircraft at ranges of up to three hundred kilometers.

Fire Controlling Systems

☐ System "Würzburg"
Both the Telefunken and Lorenz Companies were working on developing a system, working in the decimeter waveband (50 cm) suitable for deployment with anti-aircraft artillery. After developing a prototype unit, named "Würzburg A", Telefunken presented their first series ready Flak Fire Control System, the "Würzburg C" in summer of 1940. This unit had a total range of approximately thirty kilometers, its elevational

and ranging accuracies were one half of one degree and eighty to one hundred meters respectively. After further field trials by the troops this unit was improved, and introduced as standard equipment of the heavy Flak batteries. Several thousand of such units were manufactured during the course of the war. After acquiring a target, the "Würzburg C" delivered continual target data such as course, height and range. This data was then forwarded verbally by field telephone etc. to the Flak Batteries, Group Command Centres, and then to the individual Battery Commanders. The gun crews then entered these data into the guns own calculator unit.

- ☐ The "Würzburg Giant" was a later development of the "Würzburg C". Due to the increasing air speed of aerial targets, range had been increased to maximum of sixty kilometers. Deployed for home air defense purposes, this unit replaced groups of "Würzburg C" systems, more particularly by large concentrated groups of Flak Batteries.

- ☐ "Egerland" Group Fire Control Units
The Fire Control Unit "Marbach", introduced initially by Telefunken in 1942/43, was combined toward the end of the war, with the new aerial surveillance system "Kulmbach" for tactical gunnery applications. "Kulmbach" hat an acquisition range of between eighty to one hundred kilometers. Combined these two units composed the extremely effective "Egerland" system configuration, as such it was made available to the Tactical Command, Flak Artillery. "Egerland" was ideally suited to their requirements at that time and did possess some immunity to allied interference.

- ☐ Fire Control Units "Mainz" and "Mannheim"
These two "Flak" Fire Units were developed and manufactured by both Lorenz and Telefunken, considerable numbers of each were commissioned into service. They were, generally units with improved ranging accuracy, working however along very much the same lines as the "Würzburg" type systems.

7.3 The Influence of Electronic Warfare on Equipment Development

Until 1943, FuMG (radar) equipment had provided an extremely sound basis for both aerial surveillance and air defense control. However in 1943, when Allied aircraft began dropping strips of aluminium foil (chaff) during their raids, these systems all failed completely. Packets of chaff continuously released by aircraft form slowly descending cloud-like concentrations composed of vast numbers of individual strips. These strips then reflected the pulses transmitted by the FuMg (radar) equipment, in the same manner as an actual aircraft. From this time on, until the necessary "chaff" suppression equipment was developed, precise target ranging was rendered impossible. That such a simple counter measure ever came into being can be traced back to February 27th, 1942. When a British Commando Unit, raided a FuMg (radar) station located on the coast near the town of Bruneval. After capturing the station the Commando's then removed the most vital parts of the equipment and transported it back to Britain. British technicians were then able to determine exactly how the equipment functioned, after which it was possible to develop the necessary electronic counter measures, in this case "chaff".

Depending on the amount and density of "chaff" being discharged by the attacking aircraft, uncountable numbers of "light blips" appeared on the display panel of the FuMg. The presence of such large numbers of these "chaff blips" meant that the "blip" from the aircraft itself could no longer be accurately distinguished from all the others on the display. Allied combat reports concerning a series of air-raids carried out over the centre of the city of Hamburg over a period of several days, all commented that the "Flak" fire had never been so poor as it was during these particular raids.

The heavy anti-aircraft artillery had lost their most effective form of fire control. As optical target acquisition was extremely susceptible to environmental influences such as weather, darkness

etc., the "barrage" fire strategy had to be reverted to. The vast amounts of ammunition employed, bore no relationship whatsoever with the limited successes experienced.

That the FuMg (Radar) could be rendered so totally ineffective by such discharges such as "chaff", was a known, anxiously guarded secret of the German FuMg experts prior in fact, to the Allies ever deploying such means. No effective counter to "chaff" could be developed in sufficient time.

More success was experienced in countering the effects of radio "jamming", its having been anticipated and employed prior to the appearance of "chaff". Initially, for jamming purposes the Allies used transmitters located in the British Isles. Later special "jamming" aircraft carrying jamming transmitters on-board accompanied the attacking bomber squadrons on their missions. FuMg transmitters subjected to radio jamming could switch to alternative transmission frequencies. These alternative frequencies could then be used until the enemy had detected and also jammed it. It was therefore quite commonplace that during the course of an air-raid, a FuMg (radar) station was obliged to continually change its transmission frequencies.

7.3.1 Auxiliary Anti-Jamming Equipment (Electronic Counter-Counter Measures, ECCM)

Electronic Counter-Counter Measures and their associated applications imposed continually increasing technological problems. Due to the burdens caused by the steadily growing frequency of the Allied bombing raids and their intensified destructive effects on German cities, all development work was forced to take place at the fastest rate possible. Improvisations and solutions for deployment either at home or on the front, due to their ever changing priorities continually alternated one after the other in leap-frog fashion.

As the enemy themselves were also rich in ideas and applications, once one particular problem had been resolved no slackening in pace could be allowed. New enemy measures in various other military areas also required response with the necessary counters. Taking the brunt of the effects of this situation were the military personnel employed operating these new equipments. The almost round-the-clock Allied bombing raids on Western and Central Germany at this time meant that very little time was available to re-train the operational personnel on the newly developed equipments.

In the early stages, good results countering "chaff" interference were accomplished using the "Wurzlaus" Auxiliary Unit. This effected clearer marking of the "target blip" on the display screen. More experienced radar operators being able to distinguish "chaff" reflections from those of the faster moving target aircraft enabling them to continue tracking it.

As the enemy learned of this they countered by discharged far heavier concentrations of "chaff". In response to this extremely effective counter, German Air Defense deployed their new "Taunus" auxiliary equipment, which improved aircraft detection under even the most massive "chaff" interference. Still it was no fully satisfactory counter.

Eventually it was attemped to detect and track targets, even in "chaff" environments by means of acoustic devices. Whereby, as opposed to aluminium foil, other metallic combination present in an aircraft structure offered some basis for detection. However working with this further piece of auxiliary equipment (Steinhäger), additional, telling demands were now imposed on the hearing of the FuMG (radar) operators. One consequence being that experienced operators unable to cope with this additional burden had to replaced here and there. In spite of all the intensive efforts by both German Industry and the Armed Forces the problem of suppressing interference had not been completely resolved by the time the war ended.

After 1942, the clearly illuminated target blip on the Cathode Ray Tube, indicating a detected aerial target, became a thing of the past.

7.3.2 Auxiliary Aircraft Identification Equipment (Transponders)

A further, no less important problem which required resolving, for both the defending Flak batteries and Observer Corps was that of reliably determining whether a detected, potential target was ones own or an enemy aircraft. The main problem being, that reflected radar pulses from either aircraft showed identically on the radar screen. In the early war years the defending forces had been fairly well informed concerning movements of their own aircraft, alone or in groups, via air traffic control centres. However, continual breakdowns in the radio and telephone net-works, together with the general aerial situation over Germany in the later years of the war, completely reversed this situation.

From 1943 onwards, when interceptor fighters were jointly deployed with the Flak Batteries in repulsing enemy air raids this situation became untenable. This was due to the interceptor fighters often having to fly into firing range of their own ground batteries. Effective reliable means of identification became an absolute necessity in order to avoid shooting down ones own, by now rather precious aircraft. The initial discharge of colored flares in pre-arranged sequences by the air crew using Very pistols proved not only unsatisfactory, it often occurred to late. Such methods could only be retained as an absolute last resort. Besides which, the six to eight color codes which the German Luftwaffe used could soon be simulated by the enemy after a short period of observation.

The "Erstling" (first-born) (FuG 25a) and "Zwilling" (twin) (FuG 25) auxiliary radar transponders, installed in both interceptor fighters and radar transmitters for recognition purpose did somewhat advance solving the problem. Although even by the time the war ended the problem had not been fully resolved according to the military technical requirements.

Even fully appreciating the enormity of the advancements in radio technology, achieved in spite of the most adverse conditions, it must be said, that from the German point-of-view, radar development by wars end had not attained the stage of advancement which the aerial war situation dictated as being necessary. Similar critique of the Allies can also be made in this respect. Although the destruction of the German Luftwaffe and their own continually increasing aerial superiority never made this fact an important reality.

7.4 Anti-Aircraft Tank, Fire Control Systems after the Second World War

With the continual development of ever faster, lower flying attack aircraft, the task of providing effective air defense over the battlefield becomes increasingly problematic.

Therefore in the early post-war years, towed anti-aircraft guns of the artillery have each been fitted with their own individual fire control equipment. Although this led to their hit-probability performance making a rapid leap forwards, their mobility remained drastically impaired. Furthermore, due to the amount of ancillary equipment required to tow them, and the numbers of personnel to serve them they were extremely uneconomical. The problems of aerial surveillance and warning were only partially often inadequately resolved.

Anti-Aircraft Tanks developed after World War II had to be content with having radar for aerial surveillance and slant range measuring. They were not however capable of all-weather operation, nor did they meet the continually growing threat imposed by all-weather deployable attack aircraft. The statistal optical/visibility conditions pertaining to the Central European area could also not be satisfactorily fulfilled either.

7.5 The first Steps to an Autonomous, All-Weather Deployable, Anti-Aircraft Tank

The task of protecting both combat and support troops on the battlefield, without impeding their

freedom of movement, by day or night is an extremely difficult one. It was this tactical problem which provided the initial impetus for developing the anti-aircraft tank. What was called for was an armored, high mobility system, conceived in such a manner that it could operate autonomously in an all-weather environment.

Furthermore, this same system should also possess its own means of rapidly determining an aerial targets angular velocities, re-act swiftly to the same and possess a highly effective hit/kill probability.

Formulated briefly this means:
The anti-aircraft tank must not only have increased fire power when compared to its towed counter parts (eg. towed Flak 40 mm L/70 or 35 mm weapons). It must also have the mobility, cross-country characteristics comparable to those of a Main Battle Tank.

With regard to the air defense aspects of such a system, these can be divided into a series of sequential phases:
- ☐ Air space surveillance, leading to the earliest possible detection and recognition
- ☐ Precise, continual target ranging under all-weathers
- ☐ Exact, simultaneous flight path calculation and continual ballistic lead-angle renewal processing
- ☐ Accurate automatic control and continual gunlaying
- ☐ High firing cadence, with short shell flight times, minimal ballistic dispersion rates combined with highly lethal anti-aircraft ammunition.

Each of these individual phases play an equally important role in achieving successful results, similar to a chains strength being that of its weakest link. One weakness anywhere in the total system affecting total performance. Therefore the weapon system must be composed in such a manner, that each individual phase is carried out with the minimum error factor possible. Such requirements by implication alone, require that each anti-aircraft tank must possess a radar system of its own for aerial surveillance and target ranging. It must also have a computer for processing this acquired information, calculating the lead-angle ballistics on a constantly renewable basis, for the automatic control of the high performance weapons.

7.5.1 Technical Objectives

The creation of an anti-aircraft tank capable of carrying out its intended role effectively, consists in the main of resolving a whole series of multifarious problems. The difficulties of installing and stowing all of the necessary equipment, radar system, computer, weapons, power supply aggregates, crews operational stations and the like being problematic enough on their own. That each piece of this equipment must still be capable of unhindered functioning, with adequate space and good operational ergonomics for the crew being accepted as normal.

When one compares an anti-aircraft tank, equipped with its radar, computer, twin 35 mm weapon etc. and compares them against a stationary, towable system the differences are extremely impressive. When compared for example against a field unit, having such as “Superfledermaus” Fire Control, twin 35 mm weapons, power supply aggregates, towing vehicle and crew, the equipment compactness of the anti-aircraft tank becomes much clearer, it demonstrates the impressive capability placed at the disposal of the much smaller anti-aircraft tanks crew.

7.5.2 Fire Control Concepts for the Nineteen-Eighties

The anti-aircraft tank is generally obliged to carry out its combat mission in far more unfavorable conditions than those of towed anti-aircraft gun systems. Towed systems having, respective to their foreseen combat role, the tactical advantage of deploying in selected positions where cover offered by surrounding terrain can be maximally utilised. The anti-aircraft tank however, in its escort role has to stand and fight as the situation dictates. This means that its target detection equipment has

to be capable of withstanding the particularly severe demands made upon it. Its radar must function efficiently, being able to discern the differences between target and terrain echoes. Radar surveillance must be all-around, from ground level to medium altitudes.

□ One major design problem, such as the close mounting of all surveillance aids, such as optronics and radar within a turret, is maintaining each systems field-of-view. This irrespective of the turrets traversed position, weapon elevations and other surveillance aids locations. To satisfactorily overcome these impediments each device must have its own independant rotary axis for panoramic viewing. Whereby, visual limitations imposed by turret fittings, gun-barrels, radar antenna or the like must be held to an absolute minimum.

□ Electronic equipment due to the limited space available for its installation, must be contructed as compactly as possible. Such equipments operation must remain accurate and fault free in spite of its being subjected to shocks, heat and other severe, telling conditions. Compliance with these extremely stringent requirements has been assured by fully applying modern semi-conductor technology and miniaturised components.

Anti-Aircraft Tank CA1 of the Royal Netherlands Army.

8. Retrospect and the Future

A Critical Observation*

Until the Second World War, the German Military, excluding the Reichswehr, had been primarily trained for attack. Purely defensive weapons therefore were of only secondary importance. This explains why the German Wehrmacht were despatched to fight the Second World War lacking effective anti-tank ordnance. It also explains why no light anti-aircraft weapons were available to accompany the hard-core Panzer Divisions during the close, in-fighting phases of tank warfare. Even the well liked, 2 cm, self-propelled, gun systems which were available cannot disperse the illusions of being only makeshift aids. With unarmored vehicles, one is unable to provide effective support for tanks and other armored vehicles in all the battle conditions they are likely to encounter. The writing of this book, with its theme of "Self-propelled, Flak Gun-Carriages and Anti-Aircraft Tanks on Tank Chassis" expresses its own criticisms.

Air defense, similar to anti-tank defense, first came to the foreground of peoples interest by its absence. By the time the necessary remedial action had been decided upon it was already too late. Even though such changes would relieve the pressure on the hardpressed, front-line troops.

The planned deployment of troops in a battle, can be effecting the outcome of that battle. So can the effects of erroneous decisions in the conception of war materials have similar consequences. They can in fact collectively affect the outcome of a war and which side wins.

The German people have had to pay dearly for these erroneous armament concepts, amongst many other things of course. As far as these errors apply to the field of air defense, I should like to discuss three concrete examples to illustrate my viewpoint.

These involve:
1. The 1943 development of the anti-aircraft rocket.
2. Development and application of Radar technology, before and during World War II, by both Germany and Great Britain.
3. The mis-assessment of the hit-probability of the 8.8 cm Flak Cannon- and therefore the 8.8 cm Flak Battery.

Development of the Anti-Aircraft Rocket

This development was initially mooted in a memorandum, dated December 6th, 1932 when the Reich War Ministry requested that the development of such an air defense weapon and its ancillary equipment be undertaken. Known then as the "Sperr-Rakete", (Barrage Rocket) it was intended for "barrage firing" against aerial targets. It is interesting to note that development of this rocket was grouped, together with that of the 2 cm, 3.7 cm and 8.8 cm weapons under the "URGENT" priority category.

The Inspectorate of Artillery having no doubt drawn up this requirement, having in mind that the engagement of aerial targets at increased ranges and altitudes just as the aerial targets increasing flight speeds would prove problematic.

By about 1939, in general, most of the requirements specified in the 1932, "Air Defense Memorandum" had been met. The main exception

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being the development of the rocket itself, nothing having been done in this direction whatsoever.

On December 1st, 1942 almost ten years to the day later, Göring authorised an Armaments Development Program prepared by the Anti-Aircraft Artillery Inspectorate of the Luftwaffe. Whereby the development for an anti-aircraft rocket was again called for and extended to include development of guided rockets.

Even under the extremely difficult conditions which the war in the air imposed all around, this program led to seven different weapons being developed. All in spite of a growing lack of personnel and shortages of suitable raw materials. There were:

☐ Three rocket systems (Föhn, Orkan, Taifun [Storm, Hurricane, Typhoon])
☐ Two guided rocket systems (Rheintochter, Wasserfall [Rhine Daughter, Waterfall])
☐ Two drone systems (Schmetterling, Enzian [Butterfly, Gentian])

Both Industry and the Trials Research Establishment in Peenemünde had – by todays standards – worked extraordinarily quickly and effectively despite competence problemes which existed between:

☐ Armaments Ministry and Military General Staff
☐ General Staffs of Army and Luftwaffe
☐ and internally within the Luftwaffe General Staff

all of which caused at some time or other, some considerable delays in developments. For example, in 1943, the Luftwaffe refused to release the raw materials necessary for a rocket development which they themselves had ordered. The reason, at that time the Army were officially responsible for all cannon and rocket developments.

1944, saw all the proposed development plans having to be revised and concentrated around the more advanced projects. Less advanced programs having to be discontinued as a strategic necessity. Only three systems survived to undergo further development, Typhoon, Butterfly and Waterfall.

Although, early in 1945, Rheinmetall did receive official authorisation to continue developing their "Rhine Daughter" guided rocket. A missile which they had originally developed at their own initiative. It was the end of the war which led to all of the extensive pre-production preparations for manufacturing these rockets being cancelled.

Thereby, the ten years from 1932 to 1942 were totally wasted. The possiblities and potential of a new technology ignored. A technology capable of possibly stemming the weight and flow of the Allied Bombers, due to its potential not having been promptly recognised and energetically followed-up.

The Development and Application of Radar Technology

The second part of our short historical review concerns radar technology.

This development commenced:
☐ in Germany, in 1933 by Dr. Rudolf Kühnhold
☐ in England, in 1935 by Sir Robert Watson-Watt

beginning independantly from each other at almost the same time.

The work of Dr. Kühnhold resulting in the "Freya" radar equipment (2.5 m waveband), originally developed and manufactured for the German Navy, but tested in 1936 by the Luftwaffe. By the time war broke out, several of these systems had been installed to monitor the air space over the German Bight. They were not however integrated within the air defense command structure.

In December 1939, as a group of British bombers entered the German Bight on a daylight bombing mission, they were detected by a "Freya" radar system sited on the island of Wangeroog. Their measured range of 113 kilometers being reported to a Luftwaffe interceptor fighter squadron stationed in Jever. The squadron commander chose to view this report as a "Duck", delaying the

"scrambling" of his fighters until the bombers presence had been reported by observer ships anchored off the coast.

How did the British apply their early warning equipment, which in fact was technically inferior to the German System; Well, Winston Churchill comments upon this in the first volume of Book 1 of his work "The Second World War" as follows:

"By 1939, the Air Ministry applying the relatively long-wave (10 meter) Radio Equipment (radar), had established the so-called 'Coastal Chain' along the entire length of Britains East Coast . . . The Germans had produced a technically more advanced system than ours, which was superior in many ways. What would have surprised them however, was the ways and means in which we applied our discovery practically. Tightly integrating it within our complete air defense network".

The British solution was therefore more directly involved with the operational applications, rather than with the originality of the apparatus itself.

The formative years of a FuMG (radar) fire control system for the heavy, Flak artillery, also suffered in much the same manner as the Freya. The Army Ordnance Office, together with Dr. Rund and Stepp (Telefunken) had commenced prior development of a system working in the 50 cm waveband, which was almost completed by 1936. This system remained ignored and practically unused until 1939.

In 1967 at the "Convegno de la Communicazioni" Prof. Dr. Leo Brandt in his lecture titled "The History of Radar Technology" remarked, "Until the outbreak of war, no particular pressure was exercised by the authorities responsible for anti-aircraft artillery for any development being undertaken to develope a fully deployable radar system."

This explains why, that after demonstation of a laboratory radar model, in 1939 a surprise order for four thousand systems of one particular type was placed. A system which as such, did not in fact exist. After which it became necessary that the development, construction, production, trials and deployment of the system ordered, all had to run parallel to one another with foreseeable results.

The FuMG (radar) system "Würzburg A" from 1940, provided the basis for the whole family of "Flak" radar fire control units. However, it was not until 1944/1945 that the first system (MARBACH), operating in the 9 cm wavelength could be developed. Having the necessary high standards required from a fire control radar with respect to resolution, range and acquisitive accuracy (50 km/1¯). This system never was deployed in any quantity.

Assessment of the 8.8 cm Flak Weapons Firing Performance

This third complex is also included within the topic of why such delays occurred in both rocket and radar technological developments. Delays which, when reviewed and considered today, with hindsight so to speak, remain as difficult to understand as they did at the time.

In 1937, based upon the evaluatory results of firing trials, it was generally believed within the Luftwaffe High Command, that a 8.8 cm Flak Battery were able to destroy an aerial target by firing only forty-seven rounds of ammunition. This optimistic evaluation was precipitated even further when planning both the Air Defense Zone-West and local air defense of key wartime objectives at that time. However a Luftwaffe High Command report from November/December 1943 contradicted this evaluation. Trials had proven that the average quantity of 8.8 cm rounds required to destroy an aerial target was in fact four thousand and not forty-seven. A statistical differential factor of approximately 1:85. Whereby it must not be forgotten, that in a report published by the 9th U.S Air Force, 24% of the aircraft returning from their missions had been damaged by "Flak" fire.

Between 1936 and 1941, the ordnance and fire control technicians succeeded in improving the hit performance of the 8.8. cm Flak weapons, by:

☐ Improved Fire Controlling (Wurzburg Radar, Command Unit 40)

☐ Increasing muzzle velocity (from 820 to 1,020 m/s)
☐ Increasing the rate of fire form 15 to 25 rounds per minute

Evaluation of these excellent, well phased improvements did however have many other differing, but consequential aspects.

From the point-of-view of armaments technology the result was a 100% increase in the system dependant hit/kill probability.

Evaluated by the Flak artillery men themselves, this meant the lethality of an 8.8 cm Flak Battery was increased from an approximate 2% to between 4–5%.

For an aircrafts-crew coming under fire from an 8.8 cm Flak battery, their chance of survival sank from 98% to about 96%. Such reasoning containing initially the primary locical error, but also serving as a delayed confirmated of the correctness and far sightedness of the requirements established ten years earlier, in 1932 by the Inspectorate of Artillery.

The erroneous decisions and negligence air defense suffered in the latter half of the thirties were to have unforeseeable consequences. One cannot help but criticize, even today, the many incomprehensible decisions which were made at this time concerning air defense. The classic example being total rejection of Prof. Heinkel's, jet-powered aircraft, first demonstrated in 1937. That such a refusal could ever have occurred, can only have been by prejudice, ignoring new technologies which offered themselves. Now we will make a rapid leap forward to the present, and observe how modern armaments ideology has changed. It's easily discernible today, to see how the armed forces of both the Warsaw Pact and Western industrial nations have fully adopted modern technologies into their structures. In many cases in fact, furthering their own research and development programs in certain areas. This is particularly so in the field of air defense. The outcome being an extremely wide spectrum of future oriented solutions, leading to parts of the weapon system, be it in the air, or on the ground, becoming more complex and costly. A more negative aspect also, is the increased likelihood of becoming more susceptible to interference and malfunctioning. Quite a dangerous matter, likely to affect system availability and readiness in case of war. Irrespective of the fact of course that in a modern defensive pasture – unlike both World Wars – there will not be any time available for rectifying known faults, or to introduce modifications or new developments.

High performance defense technology is, at least for the industrial nations absolutely mandatory. We must and dare not ignore the risks and implications that accompany such complex technologies however, and should not rely upon them blindly. Thereby raising the difficult problem of the well-balanced, graduated "weapons mix". Where weapon compositions are structured, alone or in families of varying degrees of complexity in order to provide a broad based defensive spectrum is attaining increasing strategical importance:

Same Basic Problems of Air Defense

Air Defense of the Central European Region, irrespective of the means used, involves a series of purely defensive operations, these are:

☐ Destruction of the attacking air forces as quickly as possible.
☐ Maintaining the operational freedom of both the defending Army and Air Forces.
☐ Protecting the civilian population and vitally important infra-structure.

The armies mobile air defense systems will be permanently deployed protecting the combat troops, their support echelons, vehicles, supplies and munitions.

This also means that the effectivity of these mobile systems, directly supplements the aerial cover provided by the heavier, longer range air defense systems, in both the forward battle areas and very low to medium altitudes. As such they remain an organic component of the army generally, but can

be permutated with other types of weapon systems should need arise.

At command level, ground based air defense systems are equally rated elements. All having, in general to cope with the same problems, including:

1. Provision of, as far as conditions permit, continuous, real-time, aerial surveillance of the surrounding air-space.
2. Give sufficient advance warning of impending attack, allocate targets and control fire-power.
3. Continually monitor the effective defensive diagram, of the area they are defending, co-ordinating the various field elements according to the flow of battle, irrespective of organisational or command affiliations.

Provide systematic measuring and tuning data for co-ordinating all electronic transmissions/emissions, including those for electronic warfare.

The instrumentation necessary for furthering this are:
- ☐ fully compatible, command and surveillance aids
- ☐ well balanced mixtures and distributions of both surveillance and weapon systems. Deployed objectively, to cover the complete threat spectrum continuously.

It is only when these aids are well balanced in themselves and with the others they are expected to interoperate with that air defense can be fully effective. Any weaknesses can be expected to be detected by the enemy, within a matter of hours. After which they would be taken advantage of. It must not be forgotten, the air defense forces have to deal with the fastest and most flexible forces the enemy possesses.

Whereby, it is particulary noticeable how decisively conditions have changed since the Second World War.

- ☐ Until well into the sixties, air defense Problem No. 1, was the provision of a adequate target hit/kill capability. Aerial surveillance and target acquisition having been satisfactorily resolved.
- ☐ Today these conditions, simply stated, are exactly the opposite. Hit/kill lethality of the weapon systems is satisfactorily resolved. Now the fast, very low flying, deep penetrating potential of the aggressor has made aerial surveillance and warning Problem No. 1.

This is why these particular areas of air defense, have today, far more importance than in the past. Assessment of the differences between surveillance and combat oriented air defense systems clearly illustrate the extent of the division existing between these systems.

Fundamentals of a Future Oriented Mobile, Air Defense System

The requirements established by the Armies Air Defense Authorities, have stipulated since the end of the nineteen-fifties, that they can only carry out their task when equipped with effective combinations of gun and guided-missile systems. Each system enhancing the effectivity of the other, by its techno-physical characteristics and specific effectiveness diagrams. Both being deployable in local and urban conditions.

Both the "Gepard" and "Roland" Anti-Aircraft Tanks resulted from these requirements. Together they provide the mainstay of the armies air defense in the field being effective in the low and medium altitudes. They are indirectly reinforced by man-portable missiles, directly supported in the rear and at home by 20 mm machine cannon and heavy caliber machine guns. This is the "weapon-mix" of complex, less complex and simple weapons, a potential aggressor is likely to encounter should be decide to attack the territory of the Federal Republic of Germany.

The second mainstay of air defense are the surveillance aids for continually and completely monitoring our air space. Their operational efficiency being greatly enhanced by their frequency agility and high degrees of mobility.

It is self-explanatory, that each complete system possesses the necessary active and passive electronic and optronic sensors for facilitating surveillance and combat under electronic warfare (ECM) influences. Which means that both each individual equipment, integrated within, as well as the complete system itself, must possess the highest immunity to electronic disturbances or other means of deception likely to occur in the field. A vital necessity for the continuance of aerial surveillance.

We recognise,
That air defense must, whether it will or not, only be accomplished by deployment of complex weapons and equipment. Suitably complex surveillance and command systems will therefore also be necessary. This in order to provide the reflexes needed to re-act quickly, within the space of seconds in the correct manner.
Only an actual war, involving all of these systems, will provide the answer to which erroneous decisions have been made by those responsible today.

9. Appendix

9.1 Anti-Aircraft Weapons of World War II.

		2 cm Flak 30	2 cm Flak 38 2 cm Quad. Flak 38 (taken over from the Navy in 1940)	3 cm Flak 103/38 3 cm Twin Flak - 103/38 3 cm Quad. Flak - 103/38
Application		Self-propelled, 1 ton Half-Track. Mono Cannon (Sd. Kfz. 10/4)	Self-propelled, 1 ton Half-Track. A-A Tank Mk I A-A Tank 38 (Sd. Kfz. 140) Mono Cannon. Self-propelled, 8 ton Half-Track (Sd. Kfz. 7/1) „Furniture-Van" Prototype with Quadruple, Flak 38 Self propelled, Flak Pz. IV (whirlwind) with Quadruple, Flak 38	Twin, 103/38 „Ball Lightning". Twin-U Boat Turret Prototype Quadruple „Destroyer 45" (Prototype) 3 cm Twin, combined with 151/20 Twin in „Ball Lightning" Anti-Aircraft Tank 38 D (Prototype)
Caliber	mm	20	20	30
Muzzle Velocity (HE or AP Rounds)	m/s	900/830	900/830	750/680
Cadence	rounds per min	280	450	400/450
Means of operation		recoil loader	recoil loader	gas-operated
Weight including Barrel	kgs.	64	64	145
Barrel length	mm	1450 incl. muzzle brake	1450 incl. muzzle brake	350
Caliber length	L/	65	65	40
Rifling		8	8	16
Max. gas pressure	bar	2600	2600	2700
Length of weapons recoil	mm	30	30	120 (Barrel)
Type of recoil brake		Spring	Spring	Spring
Counter Recoil Mechanism		Spring	Spring	Spring
Elevation	o	-12 to +90	-12 to +90	-12 to +90
Maximum Firing Range	m	5000	5000	5730
Maximum Firing Altitude	m	3700	3700	4700
Round weight	kg	0.300	0.300	0.800
Round length	mm			298
Shell weight HE/AP	g	120/148	120/148	350/530

Compiled by Col. Dipl. Ing. Theodor Icken, (Retd.). Defense Technology Sub-Committee, Automotive Documentation.

3.7 cm Flak 18, 36 (3.7 cm Flak 43, 3.7 cm Twin Flak 44), (Equipment 554) Dimensions in (=) for the 3.7 cm Flak 43	5 cm Flak 41 Prototype (Equipment 56)	5.5 cm Twin Flak (Equipment 58) Prototype Most advanced German weapon of World War II Forerunner to the Russian 5.7 cm Flak.	8.8 cm Flak 18 8.8 cm Flak 36 8.8 cm Flak 37 8.8 cm Flak 41
„Furniture Van", „Eastwind" Heavy, armored Wehrmacht Tractor Self-propelled, 5 ton, Half-Track (Sd. Kfz. 6/2) Self-propelled, 8 ton, Half-Track. Mono weapon. (Sd. Kfz. 7/2) Twin Flak 44 in „Eastwind II" (Prototype and „Coelian Mk V" Anti-Aircraft Tank (Prototype)	Self-propelled 8 ton Half-Track with Mono 5 cm Flak 41 (Prototype)	Weapon Carrier with Twin, 5.5 cm Flak (Prototype) Panther Anti-Aircraft Tank with Twin, 5.5 cm Flak (Prototype)	Self-propelled, 12 ton Tractor, with 8.8 cm, Flak 18. Self-propelled, 18 ton Tractor, with 8.8 cm, Flak 37. Panther, Anti-Aircraft Tank with 8.8 cm Flak 41 (Prototype). VFW Research Flak Vehicle with either 8.8 cm Flak 37 or 41.
37 820/770 140-160 (230-250) recoil loader (gas-operated) 275 (355) 2112 57 20 2700 50 (135) Hydraulic Hydraulic -8 to +85 -7,5 to +90 (Eqpt. 43) 6500 4800 1.46 (1.57) 368 570/685	50 840/830 130 gas-operated 550 3343 67 20 2800 180 Hydraulic Spring -10 to +90 12400 9400 4.28 532 2.200/2230	55 1020 120 gas-operated 2990 4220 ? 20 2500 280 Hydraulic Spring -10 to +90 5.3 665 2.0	88 820/800, 1000/980 (41) 15-20, 20-25 (Flak 41) individual rounds 7200, 11200 (Flak 41) 4930, 6550 (Flak 41) ? 32 ? 900-1200 Hydraulic Spring -3 to +90 14860, 19800 (41) 10600, 14700 (41) 14.7/15.3 (41) 930 9.5/9.4 (41)

	2 cm Flak 30	2 cm Flak 38 2 cm Quad. Flak 38 (taken over from the Navy in 1940)	3 cm Flak 103/38 3 cm Twin Flak - 103/38 3 cm Quad. Flak - 103/38
Ammunition Supply	Flat Magazine Holding 20 Rounds 9.5 kgs.	Flat Magazine Holding 20 Rounds 9.5 kgs.	Belt Fed Belt weight with 100 shells, 93 kgs.
Sight	Ground Target Telescope 3x8 Flak sight 35	Flak sight 1x40° Suspended Reticle 38. with Ground Target Telescope 3x8°	Suspended reticle sight 38, with Ground Target Telescope
Remarks	Developed by the Rheinmetall Co. 1934 Traverse and Elevation Speeds to slow. Rate of fire inadequate	Converted from a Flak 30 to Flak 38 by the Mauser Co. Entered Series Production 1939. total production from 1939-1945 18000 units Flak 38 had same ballistic performance and ammunition as Flak 30 weapon Development of Quadruple Version, was undertaken by Rheinmetall-Borsig. Serial production began in 1940. Evaluated as good, very high firing cadence.	Developed by Rheinmetall-Borsig as aircraft weapon. Capable of armor penetration, HE Round = 32 mm at 300 meters range and 90° impact angle. AP Round = 90 mm at 300 meters range and 90° impact angle.

3.7 cm Flak 18, 36 (3.7 cm Flak 43, 3.7 cm Twin Flak 44), (Equipment 554) Dimensions in (=) for the 3.7 cm Flak 43	5 cm Flak 41 Prototype (Equipment 56)	5.5 cm Twin Flak (Equipment 58) Prototype Most advanced German weapon of World War II Forerunner to the Russian 5.7 cm Flak.	8.8 cm Flak 18 8.8 cm Flak 36 8.8 cm Flak 37 8.8 cm Flak 41
Racked Rounds with 6 Shells, 12.5 kgs. Suspended reticle sight 38 and Ground Target Telescope 3x8°	Racked Rounds with 5 Shells, 30 kgs. Ground Target Telescope 3x8°	Loading Strips with 5 Shells 29.3 kgs.	Rammer Command Unit
Ballistically the Models 36 and 37 were identical. The 36 and 37 Equipments differed only in the sighting systems used.	Detrimental were smoke and flames when firing, and the recoil shock. Production ceased after the 0-Series had been delivered.	Developed jointly by Rheinmetall and Krupp from mid 1942 on. Development had not been completed by wars-end in 1945.	Krupp first began development of the 8.8 cm Flak in 1928. Introduced into service in 1936 as the 8.8 cm Flak 36. From the types 18, 36 and 37 there were 10900 weapons deployed in August, 1944. The amount of ammunition they used in October 1944, numbered 3,100,000 rounds.

9.2 Anti-Aircraft Tank Weapons 1965 to 1980

A-A Weapons		Hispano Suiza HS 820 SL (USA M-139) (Frankr. F 2 (693)	Rheinmetall Mk20Rh202	General Electric Vulkan M 168	UdSSR SL 23/80 (AZP-23)	Rheimetall Mk25Rh205
installed in		AML (Panhard) u. AML (Panhard) 2x20 (3-600) ohne Radar	SPz Marder	M-163 6x20 AVADS	ZSU-23-4	noch nicht eingebaut
Type of Anti-Aircraft Tank (Number of crew, ammunition supply)		M3 VDA 2x20 (Panhard) (3-600) VDAA (Saviem) (2x20) ohne Radar SPz HS 30 ohne Radar (Prototyp)		Vulcan Air Defence System Fahrgestell M-113 (4-1800) mit Radar	SCHILKA 4x23/80 Fahrg. PT 76 (4-2000) mit Radar	
Caliber	mm	20	20	20	23	25
Caliber Length		85	85		80	85
Muzzle Velocity	m/s	1050	1050	1030	970	1120
Cadence	rounds-per-min	800-1000	800-1000	1000/3000 (umschaltbar)	800-1000	850-1000
Weapon Weight	kgs.	72	76	136	75	115
Weapon Lenght	mtrs.	2,565	2,61	1,88	2,576	2,99
Recoil Length	mm	22	26	6		32
Gas Pressure Required at 20°C	bar.	3800	3500	4170	3100	4200
Max. Recoil Energy	kg.	850	550	850		700
Max. Effective Range.	mtrs.	1500	1500	1200	2000	2500
Ammunition Types	kg	20mm x 139	20mm x 139	20mm x 102	23mm x 152	25mm x 137
Shell Weight	mm	0,315	0,315	0.255	0,450	0,507
Shell Length	kg	213	213	167	235,5	223
Round Weight		0,12	0,12	0,1	0,19	0,18
Ammunition Feed.		Gurt	Gurt	Gurt	Gurt	Gurt

Hispano Suiza 30 HSS-831A (KCB) 30/75	Mauser Mk 30 mm	Oerlikon KDA L/R04 35/90	Bofors M-2A1 40/60	Bofors 40/62 M-50(S-60)	Bofors 40/70	UdSSR 57/73 M 1950
AMX-13DCA-30 2x30 (3-620) erster Radar- Flakpanzer AMX-30 DCA-30 mit Radar 2x30 (3-1200) Dragon mit Radar 2x30 Fahrg. Marder-TAM (3-1200) Falcon 2x30 Fahrg. Abbot mit und ohne Radar (3-620) AML Entwicklung eingestellt: Matador 30 ZLA Flak Pz HS 30 Flak Pz SPz Neu	AAAT in Entwicklung	FlakPz 1 Gepard + CA-1 2x35 (3-680) DIVAD Gen. Dynamics (3) 2x35 Fahrg. M48A 5 (Prototyp)	M 42 (Fahrg. M 41) 2x40 (5-480) ohne Radar	VEAK 40 2x40 (3-425) mit Radar Fahrg.S-Panzer Entwicklung eingestellt	DIVAD/Ford 2x40 Prototyp Fahrg. M48A5 (3-730) AMX 13 DCA40 1x40	ZSU-57-2 2x57 (6-320) Fahrg. T-54 (mod.) ohne Radar Turm oben offen
30	30	35	40	40	40	57
75	76	90	60	62	70	73
1080	1050	1175	875	1000	1000	1000
550-650	700-800	450-550	120	300	250-300	120
173	197	562			560	
3,22	3,57	4,18	3,66	3,66	4,06	
60	45	55			230	
3800	4300	3800	3000	2700	3250	
1600	2400	2200			2500	
3000	3000	4000	3000	4000	4000	4000 (Erdziele 800)
30mm x 170	30mm x 173	35mm x 228			40mm x 365R	
0,870	0,684	1,560	2,13	2,4	2,50	6,5
285	290	386	447		534	536
0,360	0,369	0,550	0,90		0,96	2,8
Gurt	Gurt	Gurt	Gurt	Ladestreifen	Ladestreifen	Magazin

9.3 German Anti-Aircraft Tanks Armed with Cannon and Precision Guided Weapons

Zusammengestellt durch Oberst a.D. Dipl.-Ing. Theodor Icken, Fachausschuß Wehrtechnik, Dokumentation Kraftfahrwesen

		Whirlwind	M 42 (U.S. produced)	„Gepard" (Holland CA 1)	„Roland" II	„Wildcat" (AAAT)
Crew	Number	5	6	3	3	3
Chassis		KPz IV	KPz M 41	KPz Leopard	SPz Marder	Transp Pz 1 Fuchs (6x6) schwimmfähig
Combat Weight	tons	22,0	22,5	46,3	32,5	17,0
Power-to-Weight Ratio	HP/Tons	8,7/11,8	14,4/19,6	13,2/18,0	13,6/18,5	13,8/18,8
Height (Search Radar Antenna)	Raised m / Lowered m	2,76	2,85	4,17/3,29	4,31/2,95	3,40/2,70
Maximum Speed	km/h	38	67	65	70	100
Fuel Supply	ltrs.	470	530	985	640	430
Operational Rarge (roads) per DIN 70030	km	190	160	560	520	800
Weapons	Type	Flak 38	Bofors M-2 A 1	Oerlikon KDA L/R 04	Roland	Mauser Mk 30 mm
Weapons	Number	4	2	2	2	2
Weapon Caliber	mm	20	40	35	160	30
Caliber Length		65	60	90	–	76
Muzzle Velocity	m/s	900	875	1175	Höchstgeschwin-digkeit 800 6000 m in 12 s	1150
Rate of Fire – Each Weapon	rounds-per-min.	450	120	550		800
Ammunition Supply	number	3200	480	680	10	500
max. range	mtrs.	5000	4800	6500	600-6000	6500
max. altitude	mtrs.	3700	3700	4800	500-3000	4800
Search Radar		–	–	Gepard: Siemens MPDR CA-1: Hollandse Signaalappara-ten Integriertes System	Siemens Puls-Doppler	Siemens MPDR-18 mit Laser
Tracking Radar		–	–	Gepard: Siemens-Albis mit Monopuls-Doppler+ Siemens Laser Neodym YAG CA-1: Hollandse Signaalappara-ten/Monopuls-Doppler	Thomson-CSF Monopuls	Hollandse Signaal-apparaten
Engine: Mnfr./Type		Maybach/Otto	Continental/ Otto	MTU/Diesel	MTU/Diesel	Daimler/Benz Diesel
Output	kw/HP	200/272	324/440	610/830	442/600	235/320
Year Commissioned		1944	1953	1976	1978	Prototyp (1981)
User States		D	USA/A/J/JOR/ RL/YN/IR/IND/ IRQ/SP/PE/C/D	D/B/NL	D/ F = Fgst. AMX 30 USA = Fgst. M 109	—

9.4 Technical Data Gepard AA-Tank

General

Combat weight	appr. 46 t
Length (guns in 12 o'clock position)	7.68 m
Width (without track skirts)	3.27 m
Overall Height (Search Radar in lowered position)	3.29 m
Ground clearance	0.44 m
Specific ground pressure	0.96 bar
Engine output	610 kW/830 HP (DIN)
Engine output (auxiliary power unit)	66 kW/90 HP (DIN)
Maximum speed	65 km/h
Range	550 km

Radar System
- Independent search and tracking radars
- 360° scan with simultaneous target tracking
- Outstanding clutter suppression with fully coherent pulse-doppler system
- Search on the move
- Mono-pulsed tracking technique
- Search and tracking performance under ECM conditions and in a clutter environment
- Built-in test equipment for search and tracking radar
- Compact rugged and modular design

Search Radar

Frequency band	S-band
Range	15 km
Data rate	1 Hz (60 1/min)
Sub clutter visibility (SCV)	60 dB
Antenna gain	appr. 23 dB
Polarization	hor.
Operating frequencies	6 (by choice of operator)
IFF unit (interrogation only during time on target)	integrated

Tracking Radar

Frequency band	Ku-band
Operating frequencies	2 (by choice of operator)
Range	15 km
Clutter suppression	appr. 23 dB
Pulse repetition frequencies	3 (automatic)
Type of antenna	parabolic (600 mm)

Radar Controls and Displays

PPI	15 cm diameter, north-oriented range zones at 8 and 16 km (by choice of operator)
A/R-scope	10 cm Range displays

Computer
Miniaturised analog computer
All data related to the fixed vehicle coordinate systems

	Unit	Aqui-sition	Trac-king
Flight Time	s	0.4 ...10	0.4 .10
Lead angle, azimuth	m /	±1600	±1600
Lead angle, elevation	m /	±1600	±1600

Periscopes

Fixed monocular eyepiece		
Magnification (by choice of operator)	1.5 power	6 power
Field of view	50°	12.5°

Additionally, an Optical Target Indicator (OTI) can be mounted on either periscope for optical acquisition

Gun/Turret Drive

	Elevation:	Azimuth:
Maximum gun control rates		
– Acquisition	750 m /s^{-1}	1600 m /s^{-1}
– Tracking	750 m /s^{-1}	1000 m /s^{-1}
Maximum gun control acceleration		
– Acquisition	1400 m /s^{-2}	1400 m /s^{-2}
– Tracking	700 m /s^{-2}	1000 m /s^{-2}

Electric drive: Ward-Leonard generator driven from APU

Armament and Ammunition

Gun: Automatic belt-fed guns	
Calibre	Type KDA, 35 mm
Length of barrel	90 calibre = 3150 mm
Muzzle velocity	1175 m/s
Rate of fire/2 barrels	1100 rounds per min

Ammunition supply:

AA ammunition	appr. 320 rounds per gun
AP ammunition	appr. 20 rounds per gun

Auxliary Power Unit:

Liquid-cooled Multi Fuel Diesel engine	
Type OM 314	Daimler Benz
Output at 2835 1/min	66 kW

Power Supply (Battery)

Rated voltage	24 V DC

Power Supply (Generators)

Voltage	3 x 200/115 V
Frequency	380 Hz
Power	2 x 20 kVA

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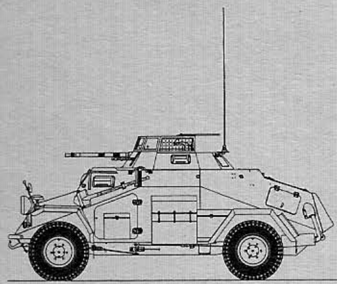

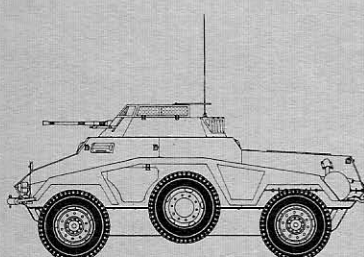

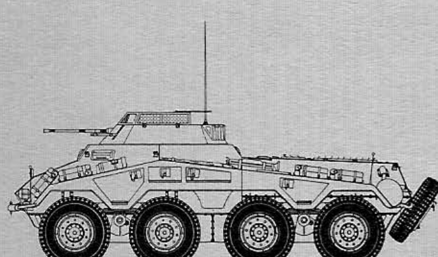

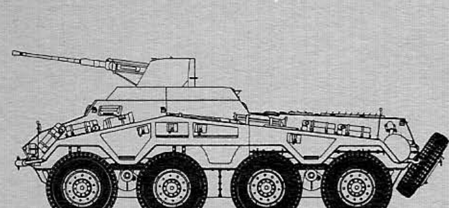

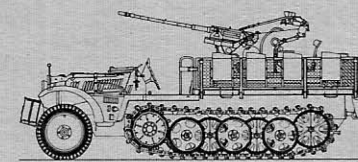

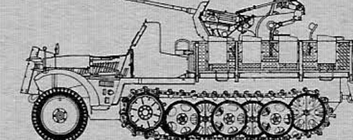

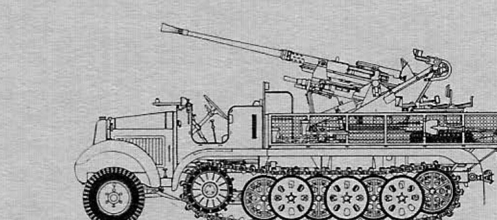

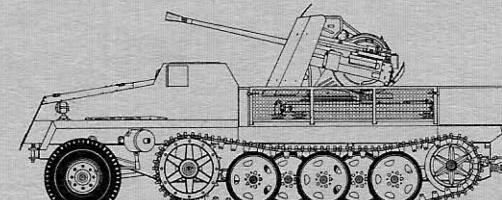

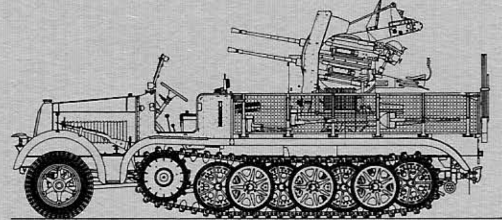

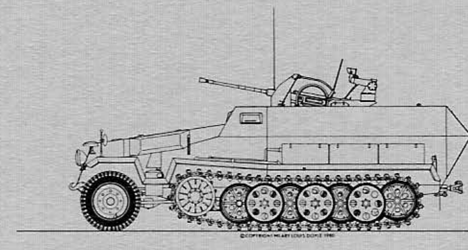

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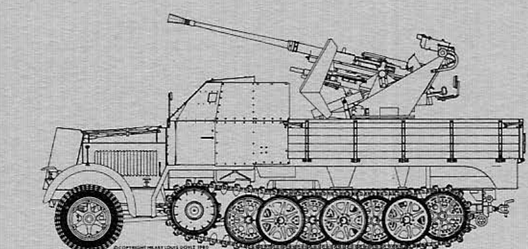

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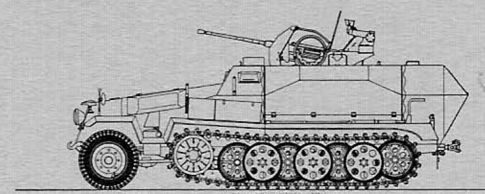

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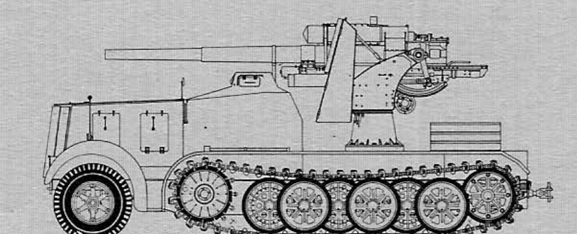

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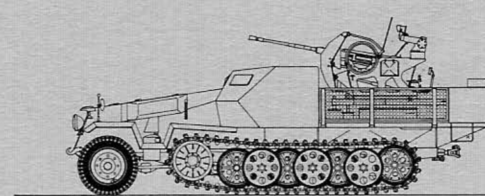

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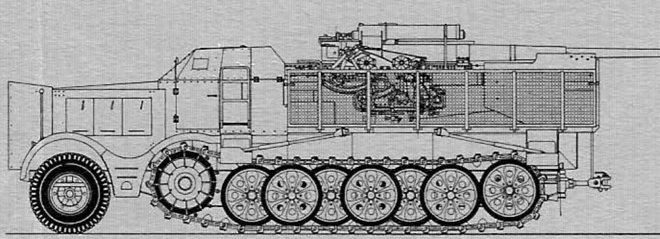

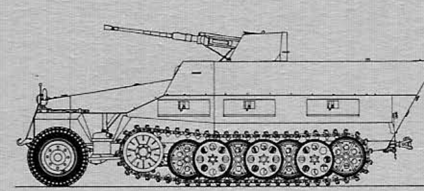

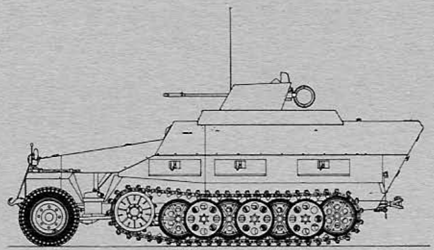

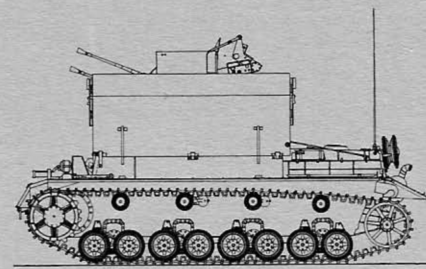

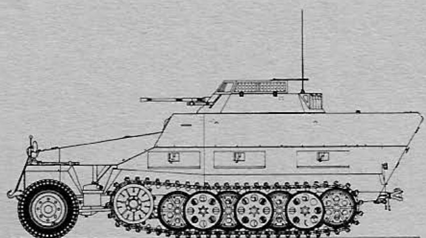

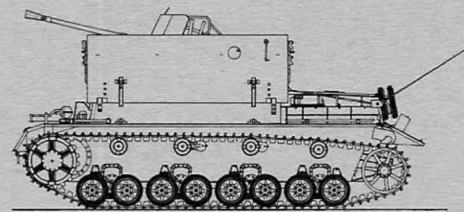

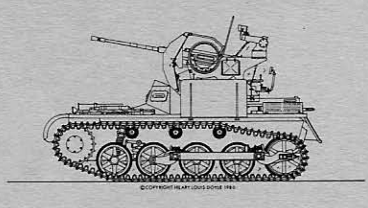
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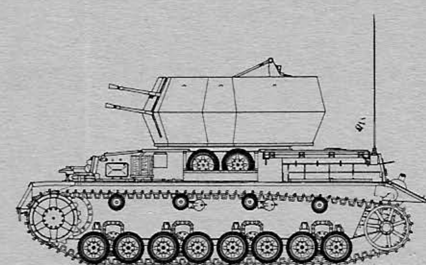

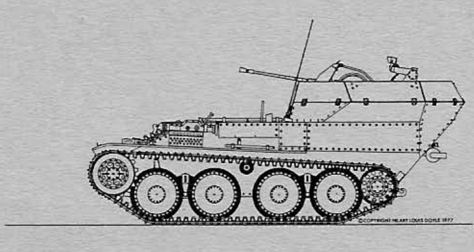
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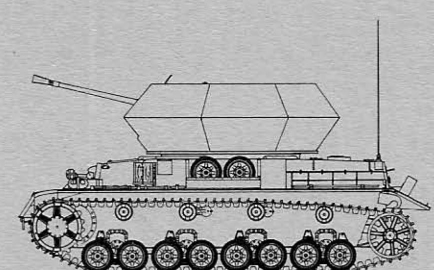

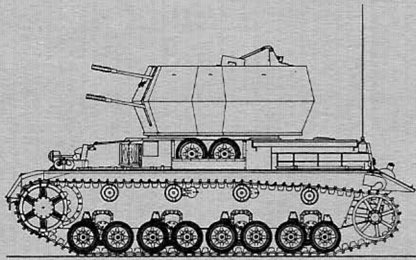

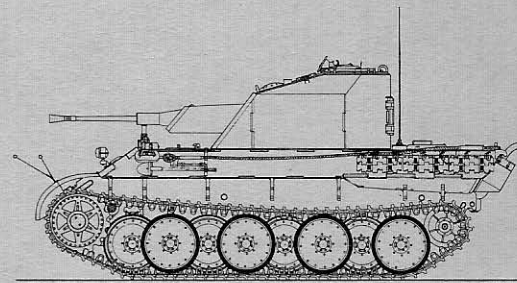

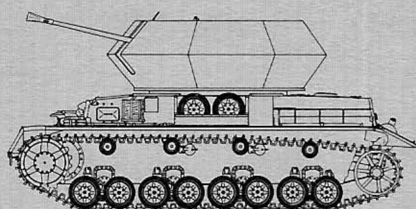

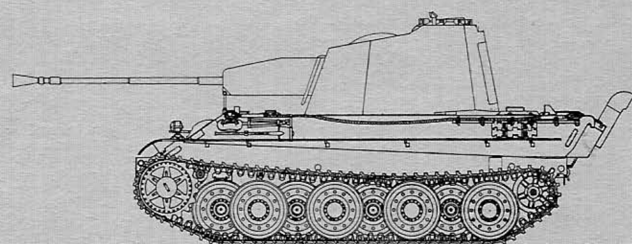

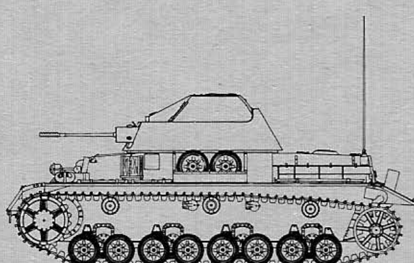

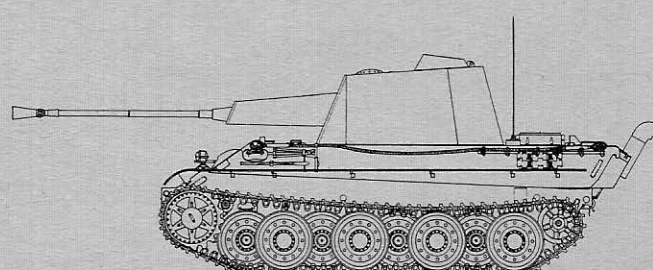

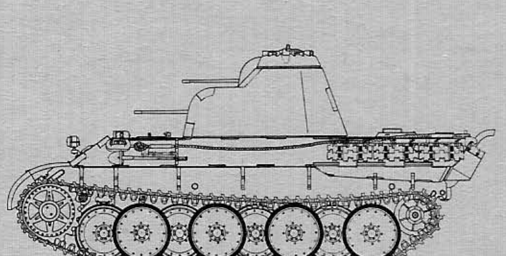

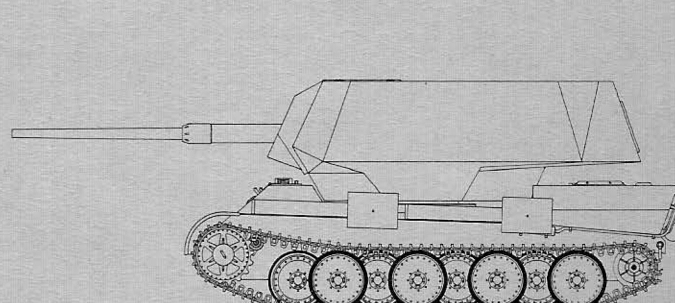
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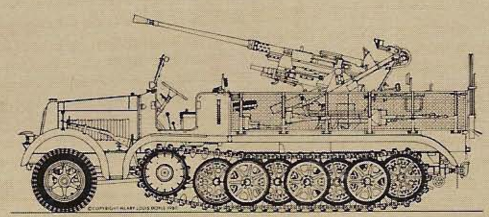
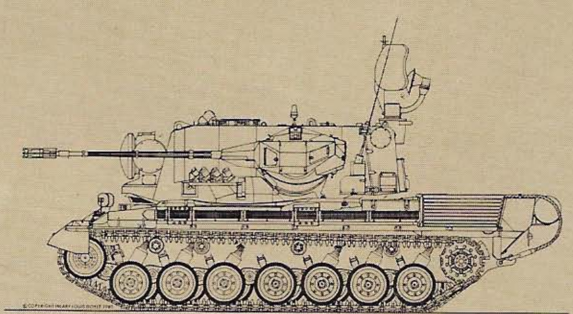
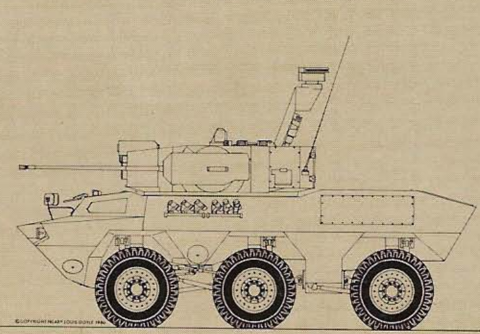
This book presents for the first time a comprehensive synopsis of the long journey which the technological development of Air Defense has travelled, from the initial conception of the Anti-Ballon Cannon in the year 1870 to todays highly complex Anti-Aircraft, Gun and Missile Tanks.
Although the history of the German Anti-Aircraft Tank has had many facets of its own, it has also in the main, remained very closely associated with the development of the battletank.
Parallel with the very rapid development of jet powered combat aircraft and their ever increasing all-weather capabillities, more and more demanding technological and/or electronic requirements have had to be established for both todays air defense systems and those of the future. It is therefore clear that in order to provide modern armies in the field with effective air cover, that modern anti-aircraft tanks must possess the highest possible standards in regards to mobility, fire power and armored protection. Furthermore, other important features such as reliability and availability for extended periods of time cannot be ignored. It has only been possible to meet these many and various demands by the consequential application of the latest electronic and optronic technologies to provide such effective air defense.
On October 29th 1980, the last of the *Gepard* anti-aircraft tanks procured for the German Army was officially handed over by Krauss-Maffei AG at their factory in Munich.
This book describes the long journey till this became a reality.







Walter J. Spielberger

The author of this book was born in Regensburg, Germany, in 1925 and is a mechanical engineer by profession. At the age of fourteen he began his technical education at the engineering department of the Altmärkische Kettenwerk GmbH, Berlin-Borsigwalde, a well-known manufacturer of tanks. After having been associated with the design of tanks since childhood he experienced his first commitment as a tank soldier in the Battle of Kursk, Soviet Union, in 1943. Wounded several times he returned to the engineering department but was again called to arms. As 1st lieutenant and commanding officer of a tank destroyer company he was taken prisoner near Hanover in 1945. From his 15th year of age Spielberger has been collecting information on tanks which has in the meantime become one of the largest privately owned collections, covering almost 35 years of intense research work. On his return from the prisoner of war camp, he was faced with the impossibility to continue an employment in his own special branch so the Volkswagen organisation offered to employ him abroad. As of 1955 Spielberger war responsible as vice president for the service and spare parts activities for most of the American West Coast. During this time American archives were in possession of remaining documents regarding German Army motorization and mechanization, captured in Germany after World War II. Most of the documents were systematically and scientifically evaluated by Spielberger for a period of years. In late 1973 he returned to Europe.
Today Spielberger is *the* internationally acknowledged expert in the field of German tank development and Army motorization. He wrote no less than 35 books describing the technical aspects of the development more thoroughly than it had been done before. His books are published in German, English, and Japanese. In addition Spielberger has been a contributor to such noted technical periodicals as Military Technology, Soldat & Technik, Truppendienst, Wehrtechnik, and others in which he deals with subjects concerning the motorization and mechanization of armies of all nations. Preparations for other books are continuing.

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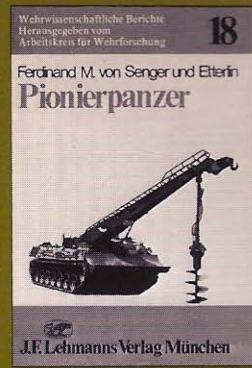

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